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(54) **REFLECTION DETECTION TYPE MEASUREMENT APPARATUS FOR SKIN AUTOFLUORESCENCE**

(71) Applicant: **KOREA ELECTROTECHNOLOGY RESEARCH INSTITUTE,** Changwon-si, Gyeongsangnam-do (KR)

(72) Inventors: **Uk Kang**, Seoul (KR); **Garry V Papayan**, St. Petersburg (RU)

(73) Assignee: **KOREA ELECTROTECHNOLOGY RESEARCH INSTITUTE,** Changwon (KR)

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USPC 600/473–480
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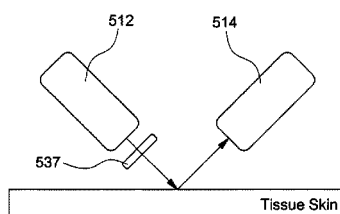(74) *Attorney, Agent, or Firm* — Patent Office of Dr. Chung Park

(57) **ABSTRACT**

The present invention provides a reflection detection type measurement apparatus for skin fluorescence, which is configured to perform light irradiation and light detection on a reference sample and a measurement target.

50 Claims, 12 Drawing Sheets
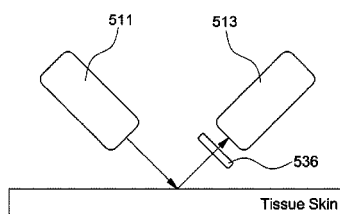
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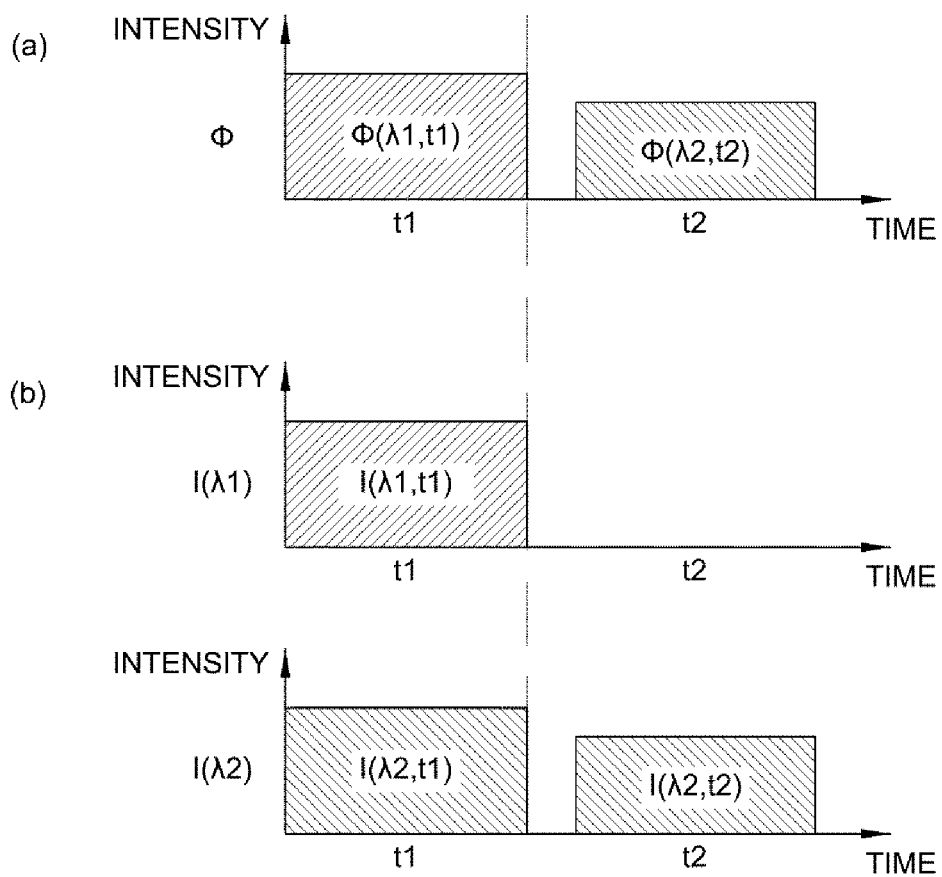U.K. Office Action for application No. 1305223.8, dated Oct. 31, 2013.
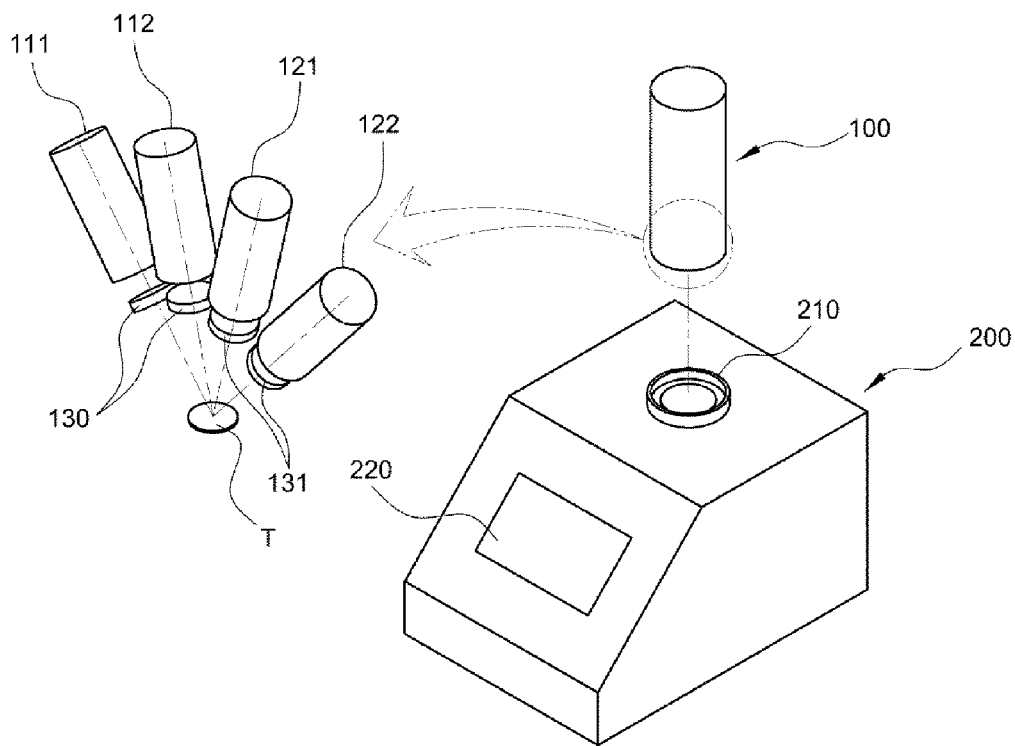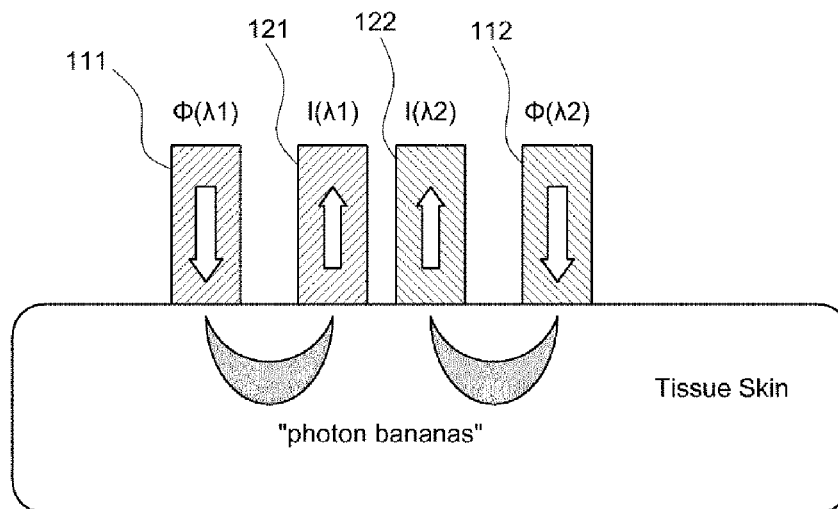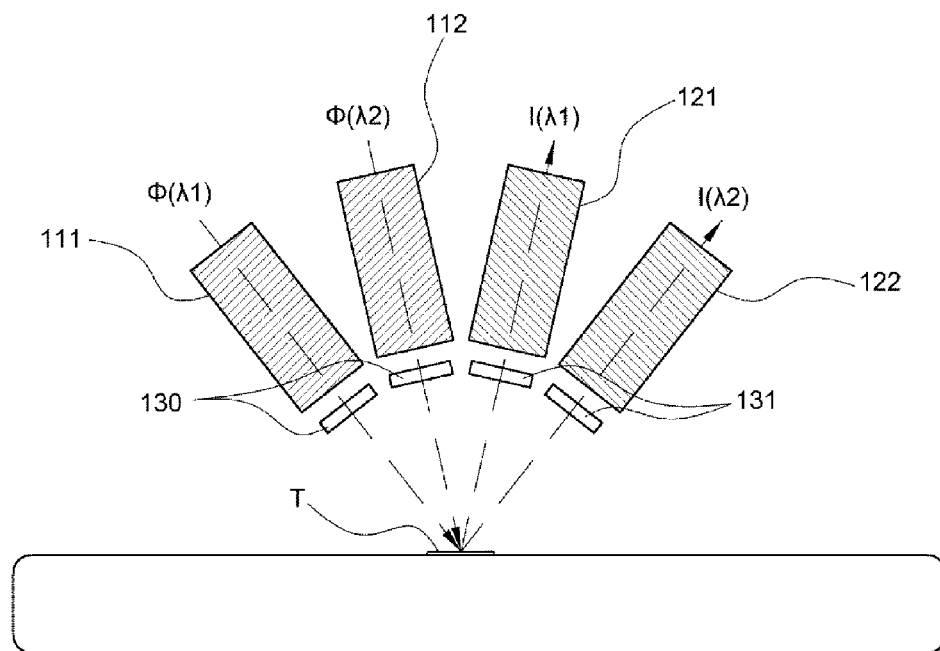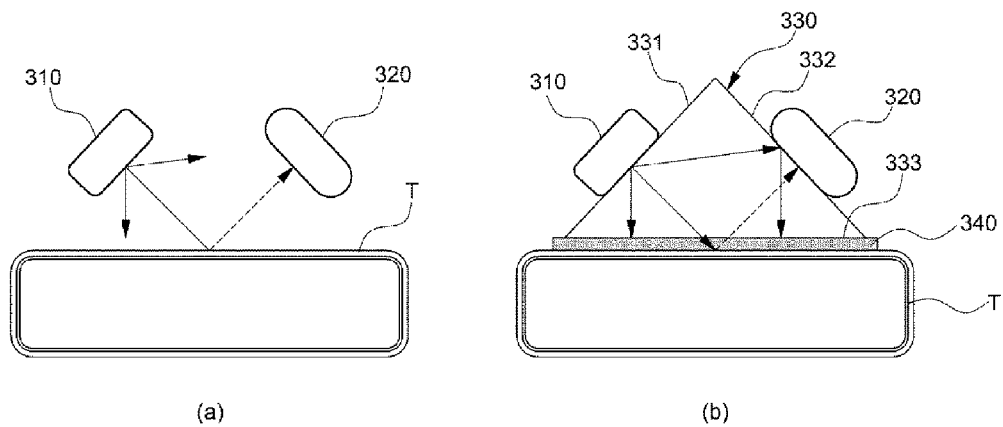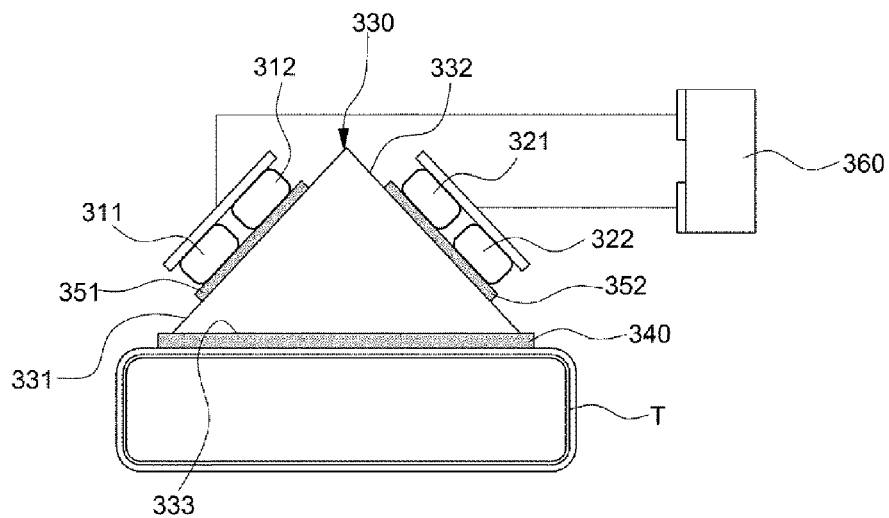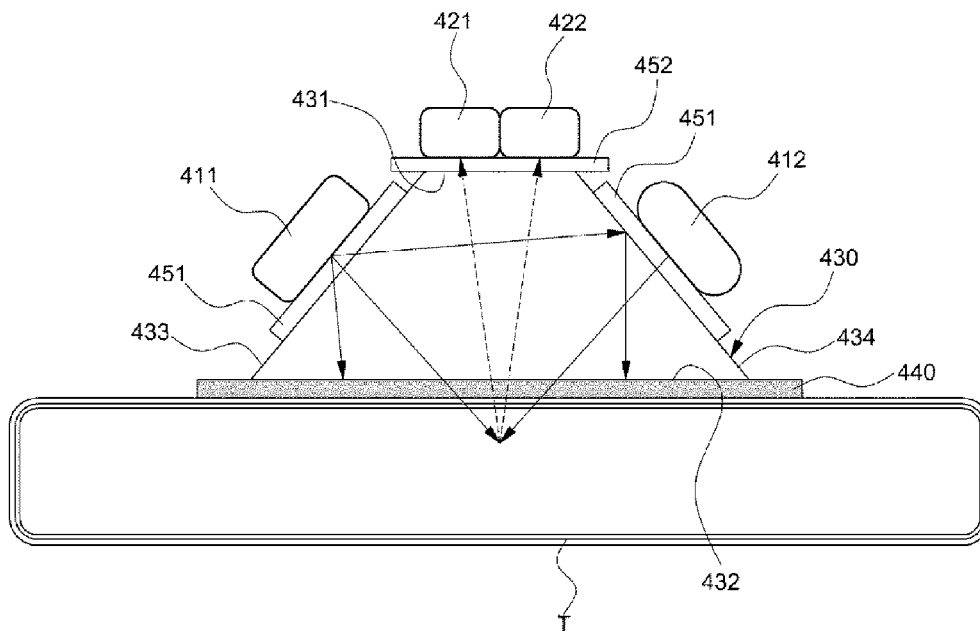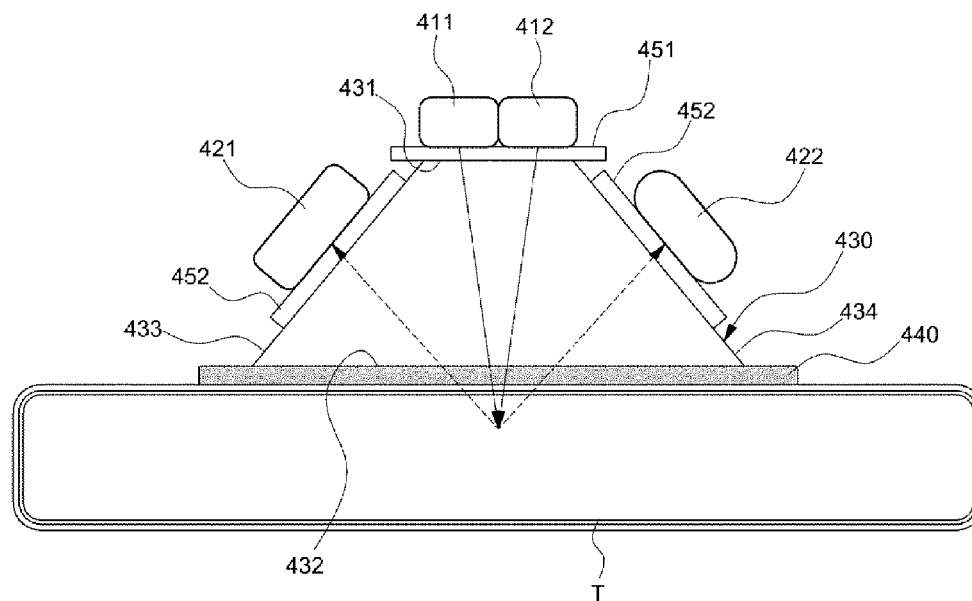
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FIG.1

FIG.2

FIG.3

FIG.4

(a)

(b)

FIG.5

FIG.6

FIG.7

FIG.8

FIG.9

FIG.10

FIG.11

450nm LED

L2

Detector

D2

Detector

D1

365nm LED

L1

FIG.12

FIG.13

521

523

513

517

519

531

525

515

514

518

520

524

526

"A" VIEW

FIG.14

524

514

518

521

511

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512

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526
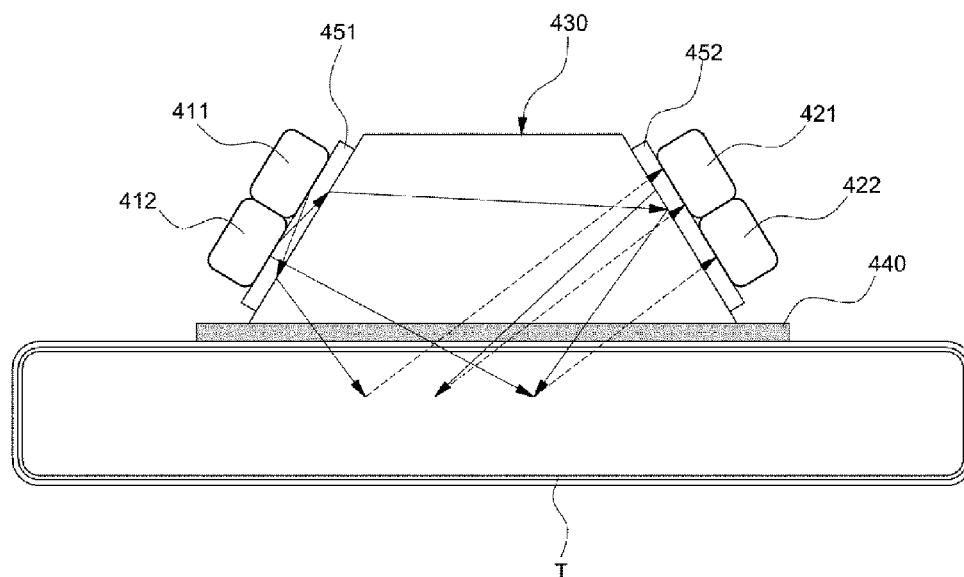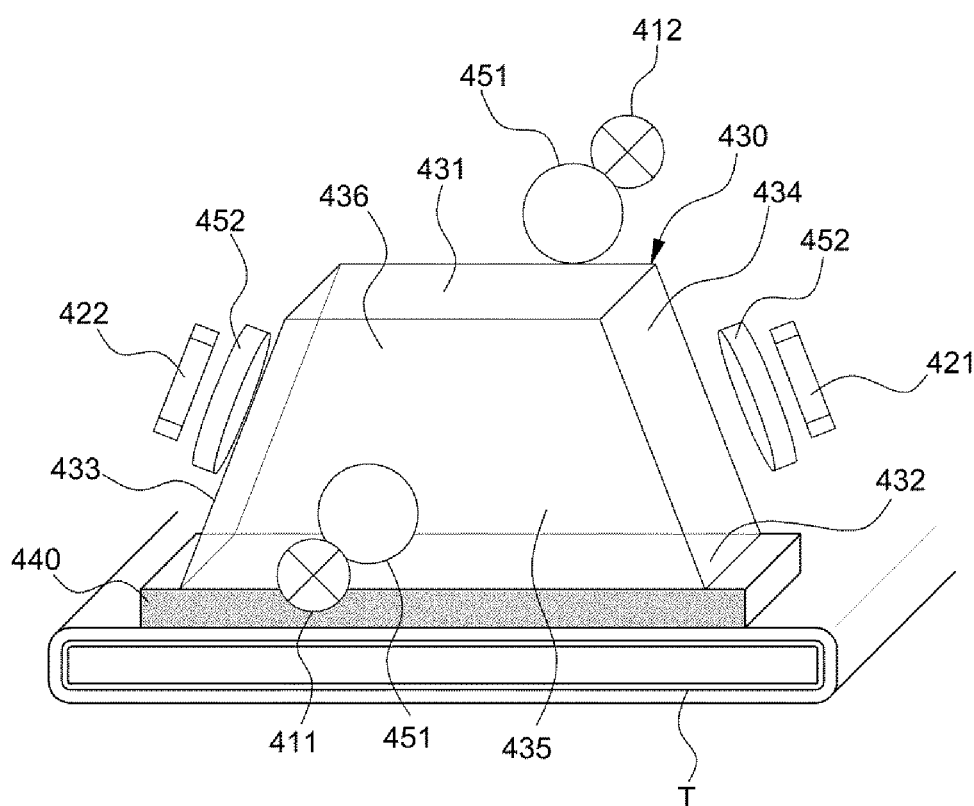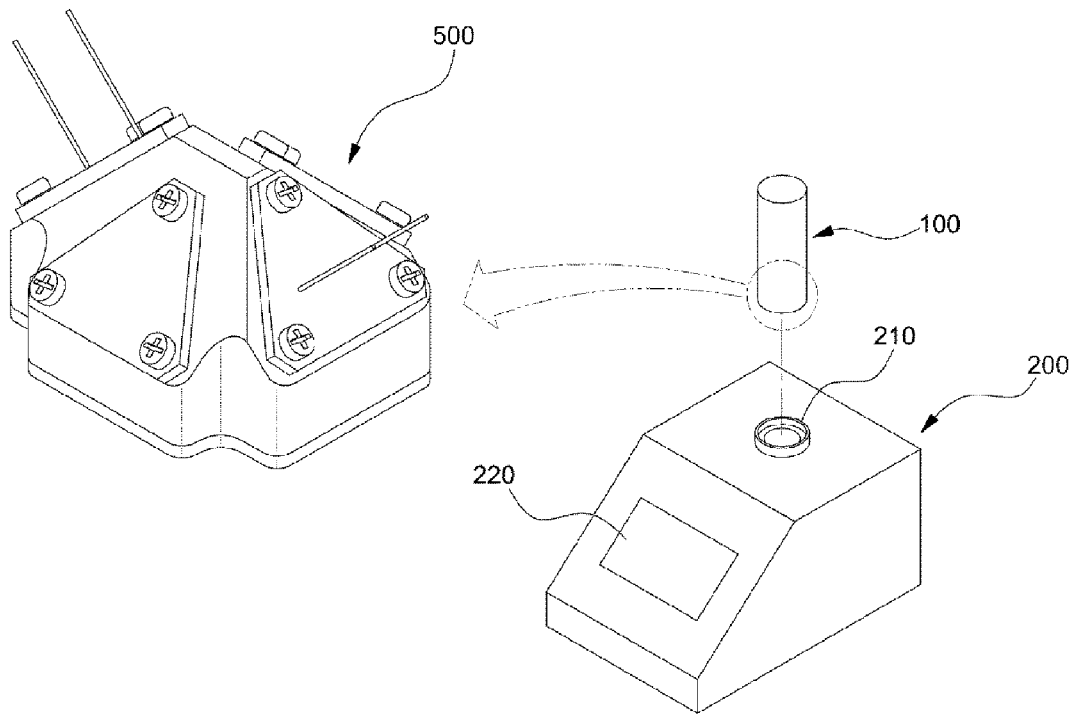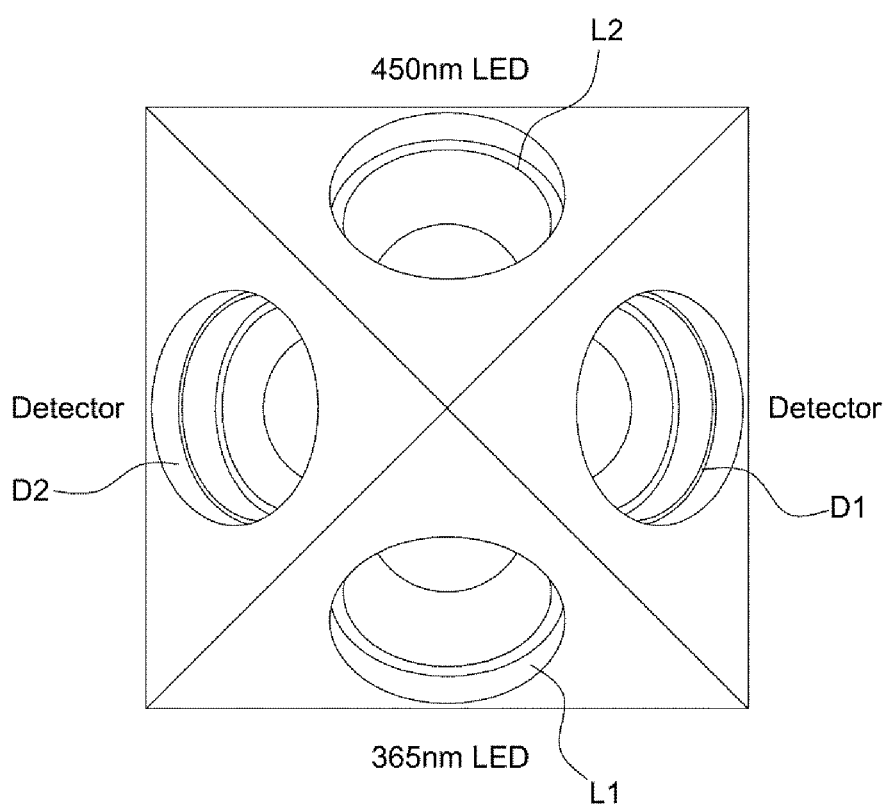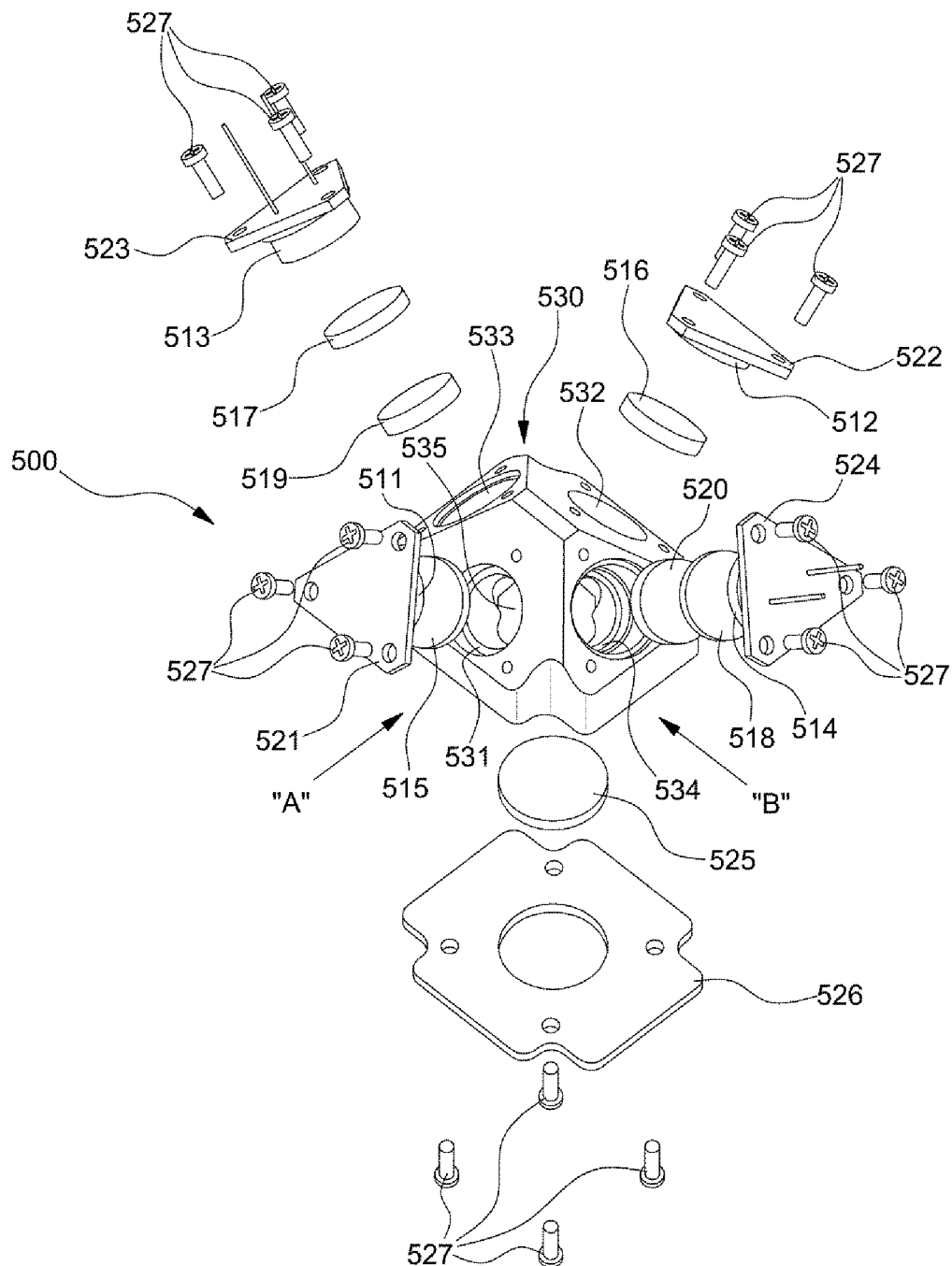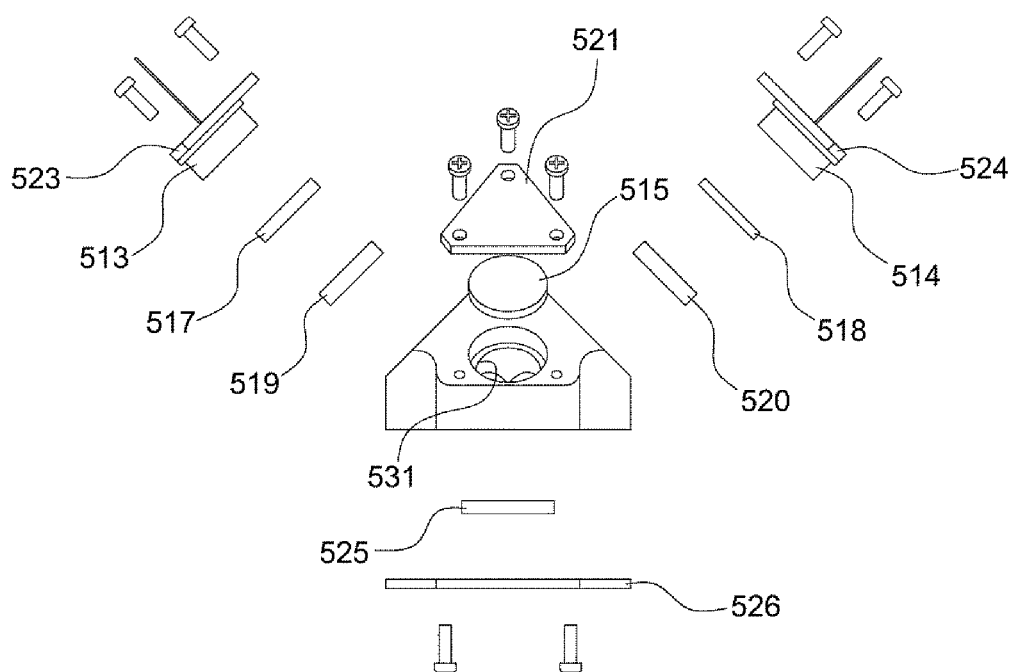
"B" VIEW

FIG.15

(a)

(b)

FIG.16

REFLECTION DETECTION TYPE MEASUREMENT APPARATUS FOR SKIN AUTOFLUORESCENCE

CROSS-REFERENCE TO RELATED APPLICATION

This application claims under 35 U.S.C. §119(a) the benefit of Korean Patent Application No. 10-2012-0028675 filed Mar. 21, 2012, and Korean Patent Application No. 10-2012-0074250 filed Jul. 9, 2012, and Korean Patent Application No. 10-2013-0009774 filed Jan. 29, 2013, the entire contents of which are incorporated herein by reference.

BACKGROUND

(a) Technical Field

The present invention relates to a skin autofluorescence measuring apparatus for diagnosing various diseases such as diabetes, by measuring autofluorescence of the skin from Advanced Glycation End-products (AGEs) accumulated in the skin.

(b) Background Art

Recently, various apparatuses using light for the purpose of diagnosis and treatment of diseases are being developed. Particularly, various apparatuses for diagnosing diseases using skin autofluorescence emitting out of the skin by excitation light irradiated from a light source are being developed and used.

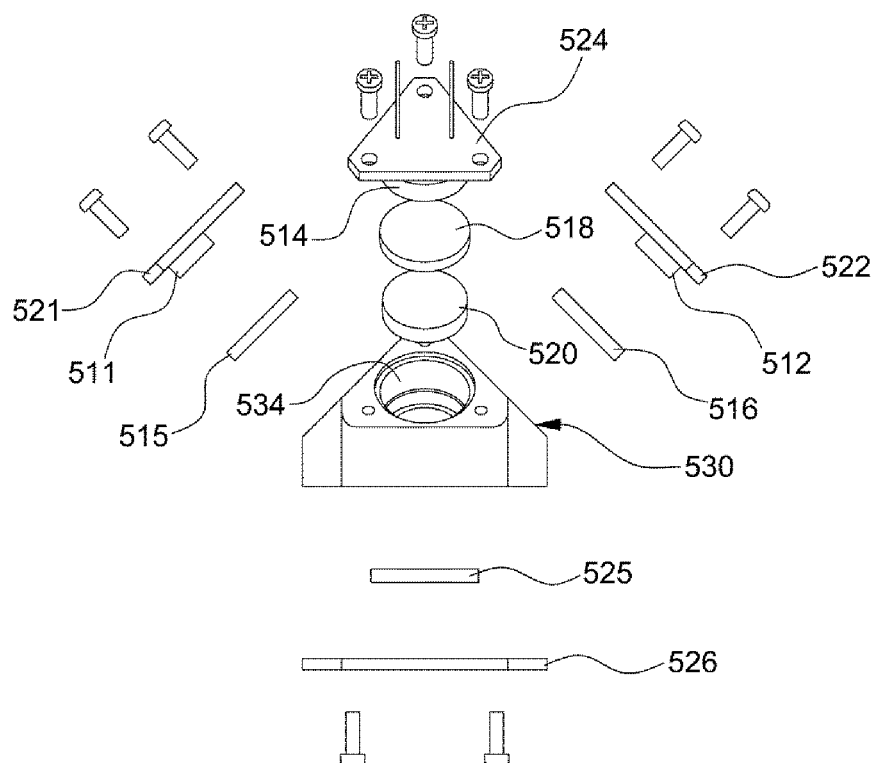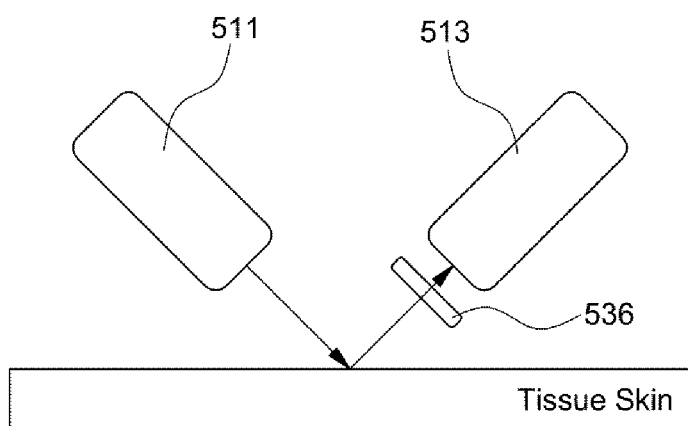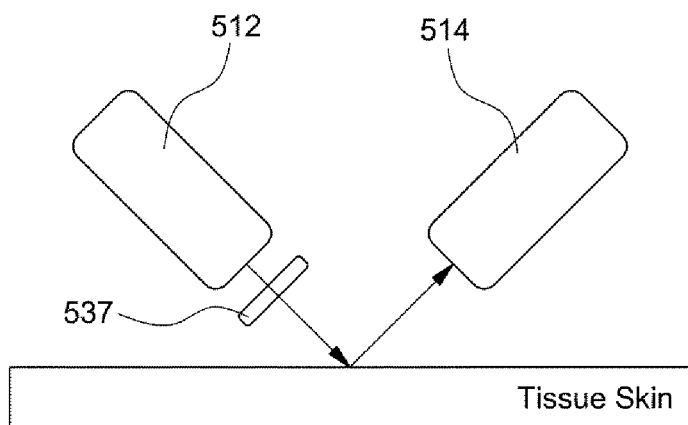The autofluorescence is the emission of light from the skin after excitation light is absorbed into the skin. Since having the biometric data inside the skin, the autofluorescence serves as a biomarker of diseases, and enables checking of the damage of physiological state of all body organs by a non-invasive method.

For example, Advanced Glycation End-products (AGEs) are formed via glycoxidation of proteins in human body as a result of Maillard reaction which impairs the functioning of many proteins. In general, exposure to cardiac risk factors such as smoking, intake of high fatty acid containing foods, hypercholesterolemia, and oxidative stress due to acute diseases such as sepsis lead to generation of AGEs. Thus produced AGEs are slowly decomposed and accumulated over a long period of time in the body. An increase in AGEs production is associated with the progress of chronic diseases such as atherosclerosis. With the aging process, AGEs tend to accumulate in the body throughout a person's life.

During the continuation of hyperglycemia, continual reactions of non-enzymatic protein glycation and glycoxidation occur, and thus AGEs, i.e., a complex of irreversible glycogen and protein, are formed. Accumulation of AGEs rapidly progresses in patients suffering from diabetes, renal failure and cardiovascular diseases. AGEs are accumulated in various tissues including skin. AGEs have the characteristics of irradiating autofluorescence (AF) at a range of blue spectrum (peak near about 440 nm) by excitation light irradiation of the UV range (peak near about 370 nm)

AGEs can be used as a bio marker regarding a series of diseases, and enable to evaluate physiological damages of the whole body organs by measuring autofluorescence of skin using a non-invasive method. That is, AGEs can predict long-term complications in age-related diseases. In particular, the quantity of skin autofluorescence increases in patients suffering from diabetes and renal failure, and relates to the progress of vascular complications and Coronary Heart Disease (CHD). The AGE accumulation can be measured by skin autofluorescence by a non-invasive method, a non-invasive

clinical tool useful for the risk evaluation of long-term vascular complications under environments associated with the accumulation of AGEs and diabetes.

US Patent Application Publication No. 2004-186363 (hereinafter, referred to as Reference 1) discloses technology of evaluating AGEs by measuring skin fluorescence near the forearm of a patient as a method and apparatus that are proposed for AGE evaluation using skin autofluorescence measurement.

In Reference 1, an excitation light source is a blacklight fluorescent tube that emits light in a UV wavelength range of about 300 nm to about 420 nm. The collection and recording of light are performed by an optical fiber spectrometer. In order to increase a measurement area, the end surface of an optical fiber is disposed apart from a transparent window of the apparatus by a certain distance (d is about 5 mm to about 9 mm). In order to reduce an influence of light reflected from skin and window, the optical fiber is disposed oblique to the surface of the window at about 45 degrees.

Specifically, in Reference 1, the end surface of the optical fiber for collecting light is disposed as distant as possible from a target spot. In this case, the area of the target spot to be measured is about 0.4 cm^2.

However, there is a limitation in the above method that a fluorescent signal that is collected is considerably reduced as the measurement distance (d) increases to increase the measurement area of the target spot. Accordingly, in Reference 1 according to a related art, the reliability of data detection may be reduced due to a limitation of the size of the skin area that can be measured. Particularly, such an accuracy limitation is considerably represented in parts such as moles, vessels, and wounds that are heterogeneous spots of skin.

Meanwhile, US Patent Application Publication No. 2008-103373 (hereinafter, referred to as Reference 2) discloses an apparatus for measuring AGEs to perform a screen test of a diabetic. Similarly to Reference 1, the apparatus disclosed in Reference 2 includes an optical fiber spectrometer to perform fluorescence measurement on the forearm skin. However, unlike in Reference 1, optical fiber probes are provided in a form of bundle including multiple branches.

In the apparatus of Reference 2, UV light and blue light emitting from light-emitting diodes are irradiated on the forearm of a subject through optical fiber probes, and skin fluorescence and diffusion reflection light emitting therefrom are collected through the probes. The collected light is wavelength-dispersed in a spectrometer, and then detected by a linear array detector. Two branches (illumination fibers; channel **1** and channel **2**) of the optical fiber probe serve to irradiate light on a target spot, and a third branch (collection fibers) delivers light from the target to a multi-channel spectrometer. The end surface of a tissue interface, where the branch bundles of the optical fiber probes are combined, becomes in contact with skin to be irradiated.

Light from a white light LED is emitted from one branch of the optical fiber probe for reflection light spectrum measurement, and light from an appropriate LED among LEDs emitting light of ultraviolet to a blue light spectrum range is emitted from another branch of the optical fiber probe via a switching apparatus. Various wavelengths can be selected to select optimal fluorescence excitation conditions. The reflection light spectrum measurement is used to detect autofluorescence generated due to melanin and hemoglobin and compensate for the measurement result. Respective optical fibers are disposed in the optical fiber bundle by a certain sequence. Optical fibers from three branches of the optical fiber bundle are sequentially disposed in a mosaic pattern at an interval of b=0.5 mm.

In Reference 2, since light is irradiated on the forearm of a subject through an optical fiber probe, the optical fiber probe is included as an optical-transmission medium. However, the optical fiber probe has a limitation in delivery loss which occurs according to the small diameter and low numerical aperture of optical fibers.

Additionally, since both apparatuses disclosed in References 1 and 2 include optical fibers in a light-receiving unit that receives light, there is an inherent limitation in the optical fiber probe of the light-receiving unit. Since References 1 and 2 are configured to use an optical fiber spectrometer and a linear array detector, there is a limitation in that the autofluorescence signal wavelength of AGE becomes relatively smaller in a detection area that is occupied by the linear array detector. Accordingly, a detected fluorescence signal is dispersed, and the light intensity of a wavelength to be detected by the linear array detector becomes relatively smaller. Also, due to the optical fiber probe and optical fiber spectrometer, it is difficult to minimize facilities.

On the other hand, the diagnosis apparatuses disclosed in References 1 and 2 have a limitation in that it is impossible to diagnose diseases such as a diabetic foot accompanied by diabetes.

The diabetic foot is a sort of serious complications that incur a diabetic foot ulcer and a lower leg amputation according to the progress of diabetes. It is reported that the diabetic foot occurs in about 15% of all patients with diabetes and about 40% to about 60% of all lower leg amputation patients are diabetic patients. The diabetic foot ulcer is a cause in about 80% or more of all lower leg amputation patients. About 90% or more of patients with the diabetic foot can be cured without amputation when they are appropriately treated at an early stage. The autofluorescence measurement test can be used for an early diagnosis of the diabetic foot. At an early stage of the diabetic foot, the diabetic foot usually occurs in one foot before its progress in the other foot. Accordingly, the early diagnosis of the diabetic foot using the fluorescence test can be performed by comparing and evaluating the fluorescence degree of skin of the symmetrical foot part. Therefore, for early diagnosis of diseases such as diabetic foot together with typical diabetes, there is a need for the development of an apparatus that enables a selective diagnosis on body parts to be measured.

Particularly, for implementing the selective diagnosis apparatus, the miniaturization and the mobility of the apparatus has to be first prepared. Accordingly, the efficiency of light irradiation and fluorescence detection in the apparatus is needed.

Meanwhile, although such a selective diagnosis is performed on body parts, the intensity of the fluorescence generated from the skin is affected by the light scattering and absorption occurring inside the skin as well as fluorescence substances included in the skin.

Therefore, it is very important to improve the efficiency of the light irradiation and the fluorescence detection and reduce a measurement error due to the light scattering and absorption inside the skin in order to achieve an exact diagnosis on selective diagnosis parts for more clearly discriminating between persons with diseases and persons without diseases.

The above information disclosed in this Background section is only for enhancement of understanding of the background of the invention and therefore it may contain information that does not form the prior art that is already known in this country to a person of ordinary skill in the art.

The above information disclosed in this Background section is only for enhancement of understanding of the background of the invention and therefore it may contain infor-

mation that does not form the prior art that is already known in this country to a person of ordinary skill in the art.

SUMMARY OF THE DISCLOSURE

The present invention provides a reflection detection type measurement apparatus for skin fluorescence, which can simply correct a measurement error of skin fluorescence due to light scattering and absorption generated in the skin and reflected light of irradiation light from the skin surface, in measuring skin fluorescence.

The present invention also provides a reflection detection type measurement apparatus for skin fluorescence, which can increase a diagnosis possibility of diseases such as diabetes by exactly evaluating diagnosis factors such as AGEs from corrected skin fluorescence values.

The present invention also provides a reflection detection type measurement apparatus for skin fluorescence, which can improve the optical efficiency by efficiently concentrating light from a light source on the skin tissue and minimizing the specular reflection from the surface of the skin tissue, in measuring skin fluorescence.

The present invention also provides a reflection detection type measurement apparatus for skin fluorescence, which can improve the optical concentration and the optical uniformity by uniformly concentrating light irradiated from a light source to a measurement target.

The present invention also provides a reflection detection type measurement apparatus for skin fluorescence, in which an optical system and a light source system can be simply configured to conveniently perform a diagnosis process.

In one aspect, the present invention provides a reflection detection type measurement apparatus for skin fluorescence, which is configured to perform light irradiation and light detection on a reference sample and a measurement target, the apparatus including: a first light source irradiating excitation light; a second light source irradiating light of a wavelength different from that of light from the first light source; first optical detector and second optical detector disposed to detect two different wavelengths with respect to a fluorescence signal and a reflected light signal; a light source switching controller for controlling turning on/off of the first light source and the second light source; and an operator calculating a corrected skin fluorescence signal from the fluorescence signal and the reflected light signal detected by the first optical detector and the second optical detector, wherein the second light source irradiates light of the same wavelength range as skin fluorescence excited by the excitation light from the first light source and emitted.

In an exemplary embodiment, the present invention provides a reflection detection type measurement apparatus for skin fluorescence, comprising: a light source irradiating excitation light; an optical detector for detecting a fluorescence signal caused by the excitation light irradiated from the light source; and an optical prism configured to transmit the excitation light irradiated from the light source to a measurement target and transmit the fluorescence signal to the optical detector, wherein the optical prism has a lower surface connected to the measurement target and two or more upper surfaces over which the light source and the optical detector are disposed.

In another exemplary embodiment, the apparatus may further include an optical connector disposed under the lower surface of the optical prism and contacting the measurement target.

In still another exemplary embodiment, the optical connector may include a connection layer formed of a liquid material or an elastic material between the optical prism and the measurement target.

In yet another exemplary embodiment, the optical prism may include two upper inclination surfaces and a lower surface adjacent to the measurement target, and may be a triangular prism having a triangular section.

In still yet another exemplary embodiment, the first light source and the second light source may be disposed over one upper inclination surface of the optical prism, and the first optical detector and the second optical detector may be disposed over the other upper inclination surface of the optical prism.

In a further exemplary embodiment, the optical prism may include two upper inclination surfaces, an upper surface connected to the two upper inclination surfaces, and a lower surface adjacent to the measurement target, and may be a trapezoidal prism having a trapezoidal section.

In another further exemplary embodiment, the first light source and the second light source may be disposed over one upper inclination surface of the optical prism, and the first optical detector and the second optical detector may be disposed over the other upper inclination surface of the optical prism.

In still another further exemplary embodiment, the first light source and the second light source may be disposed over one upper inclination surface and the other upper inclination surface of the optical prism, respectively, and the first optical detector and the second optical detector may be disposed over the upper surface of the optical prism.

In yet another further exemplary embodiment, the first optical detector and the second optical detector may be disposed over one upper inclination surface and the other upper inclination surface of the optical prism, respectively, and the first light source and the second light source may be disposed over the upper surface of the optical prism.

In still yet another further exemplary embodiment, the optical prism may include four upper inclination surfaces, an upper surface connected to the four upper inclination surfaces, and a lower surface adjacent to the measurement target, and may be a frustum of a quadrangular pyramid having a trapezoidal section.

In a still further exemplary embodiment, the first light source and the second light source may be disposed over two upper inclination surfaces of the optical prism, respectively, and the first optical detector and the second optical detector may be disposed over the other upper inclination surfaces of the optical prism, respectively.

In a yet still further exemplary embodiment, the first light source and the second light source may be disposed over the two upper inclination surfaces that are opposite to each other, and the first optical detector and the second optical detector may be disposed over the other upper inclination surfaces that are opposite to each other.

In a yet still further exemplary embodiment, the apparatus may further include a polarizer and a cross polarizer are disposed between the optical prism and the light source and between the optical prism and the optical detector, respectively.

In an exemplary embodiment, the light source switching controller may control the first light source and the second light source such that turning-on states of the first light source and the second light source are separated from each other in time.

In another exemplary embodiment, the switching controller may be configured to detect the fluorescence signal and the

reflected light signal from the first light source and the reflected light signal from the second light source while continuously repeating a process of sequentially turning on and off the first light source and the second light source.

In still another exemplary embodiment, the measurement target and the reference sample may be selectively located on optical paths of the first light source and the second light source.

In yet another exemplary embodiment, the first light source may irradiate light with a wavelength of 370±20 nm.

In still yet another exemplary embodiment, the second light source may irradiate light with a wavelength of 440±20 nm.

In a further exemplary embodiment, the switching controller may control all the first light source and the second light source to be turned off before turning on each of the light sources.

In another further exemplary embodiment, when the switching controller turns off all the first light source and the second light source, the first optical detector and the second optical detector may measure dark signals, and the operator may store the measured dark signals and compensate for the fluorescence signal and the reflected light signal detected from the stored dark signals.

In still another further exemplary embodiment, the switching controller may control the first light source and the second light source to repeat turning on/off at a period of about 10 Hz to about 100 Hz.

In yet another further exemplary embodiment, the apparatus may further include an optical detector switching controller for controlling turning on/off of the first optical detector and the second optical detector.

In still yet another further exemplary embodiment, the apparatus may include: a measurement scanner including the first light source, the second light source, the first optical detector, and the second optical detector; and a main body electrically connected to the measurement scanner and including the operator, wherein the optical sensor is detachable from the main body.

In a still further exemplary embodiment, the measurement scanner may be formed in a hand-grippable form, and may include the first light source, the second light source, the first optical detector, and the second optical detector disposed at one end portion thereof.

In a yet still further exemplary embodiment, the measurement scanner may include a memory for storing detected data.

In a yet still further exemplary embodiment, in the measurement scanner, the first light source, the second light source, the first optical detector, and the second optical detector may be vertically disposed parallel to each other such that light irradiation and light detection is vertically performed on the measurement target.

In a yet still further exemplary embodiment, in the measurement scanner, the first light source, the second light source, the first optical detector, and the second optical detector may be obliquely disposed to be inclined to each other at certain angles such that light irradiation and light detection is obliquely performed on the measurement target.

In a yet still further exemplary embodiment, the first light source, the second light source, the first optical detector, and the second optical detector may be disposed so as to perform the light irradiation and the light detection from the same location.

In a yet still further exemplary embodiment, the first light source and the first optical, and the second light source and the

second optical detector may be all disposed to be inclined to each other at an angle of about 45 degrees.

In a yet still further exemplary embodiment, the main body may include a mounting part in which the measurement scanner is mounted, and the measurement scanner may be configured to be removable from the mounting part.

In a yet still further exemplary embodiment, the first light source, the second light source, the first optical detector, and the second optical detector may be disposed at one end portion of the measurement scanner, and the mounting part may have an aperture structure formed therein and having a shape matching a shape of the one end portion of the measurement scanner.

In a yet still further exemplary embodiment, the aperture structure of the mounting part may be configured such that the reference sample is optically connected to the first light source, the second light source, the first optical detector, and the second optical detector of the measurement scanner.

In a yet still further exemplary embodiment, when the measurement scanner may be mounted in the mounting part, the main body may perform measurement on the reference sample, and may receive detection data of the measurement target and the reference sample stored in the measurement scanner to allow the operator to calculate the corrected skin fluorescence signal.

In a yet still further exemplary embodiment, the mount part may include a charging terminal for the measurement scanner, and may allow the measurement scanner to be charged when the measurement scanner is mounted in the mounting part.

In a yet still further exemplary embodiment, the measurement scanner may include two pairs of cross-polarizers disposed thereon.

In a yet still further exemplary embodiment, the first light source and the second light source may be connected to an end of a measurement target side of the measurement scanner via a light guide.

In a yet still further exemplary embodiment, the first optical detector and the second optical detector may be connected to an end of a measurement target side of the measurement scanner via a light guide.

In a yet still further exemplary embodiment, the main body may further include a display part, and the display part may output the corrected skin fluorescence signal calculated in the operator.

In a yet still further exemplary embodiment, the operator may calculate a skin fluorescence value corrected by the following equation:

$$AF_{corr}=K[I(\lambda 2,t1)/I_0(\lambda 2,t1)]/\{[R(\lambda 1)]^{k1}[R(\lambda 2)]\}^{k2}$$

(here, $R(\lambda 1)=I(\lambda 1,t1)/I_0(\lambda 1,t1)$: Diffuse reflection coefficient in excitation wavelength;

$R(\lambda 2)=I(\lambda 2,t2)/I_0(\lambda 2,t2)$: Diffuse reflection coefficient in emission wavelength;

$I(\lambda 2,t1)$: Inherent fluorescence (skin fluorescence) signal value of skin tissue;

$I(\lambda 1,t1)$: Reflected light signal value of skin tissue in excitation light wavelength;

$I(\lambda 2,t2)$: Reflected light signal value of skin tissue in emission light wavelength;

k1, k2: Exponents of correction function with respect to excitation light and emission light wavelength;

$I0(\lambda 2,t1)$: Inherent fluorescence signal value of reference sample;

$I0(\lambda 1,t1)$: Reflected light signal value of reference sample in excitation light wavelength; and

$I0(\lambda 2,t2)$: Reflected light signal value of reference sample in emission light wavelength).

K: Ratio coefficient that considers the features of the used reference samples.

Other aspects and exemplary embodiments of the invention are discussed infra.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other features of the present invention will now be described in detail with reference to certain exemplary embodiments thereof illustrated the accompanying drawings which are given hereinbelow by way of illustration only, and thus are not limitative of the present invention, and wherein:

FIG. 1 is a graph illustrating the intensities of light inputted from a light source and light detected by an optical detector which are shown according to time to explain the measurement principle of a reflection detection type measurement apparatus for skin fluorescence according to an embodiment of the present invention;

FIG. 2 is a view illustrating a reflection detection type measurement apparatus for skin fluorescence according to an embodiment of the present invention;

FIG. 3 is a view illustrating an exemplary arrangement of light sources and optical detectors when there is no gap between the light sources and the optical detectors and a target skin in a reflection detection type measurement apparatus for skin fluorescence according to an embodiment of the present invention;

FIG. 4 is a view illustrating an exemplary arrangement of light sources and optical detectors when there is a gap between the light sources and the optical detectors and a target skin in a reflection detection type measurement apparatus for skin fluorescence according to an embodiment of the present invention;

FIG. 5 is a view illustrating an optical prism and an optical connector in a reflection detection type measurement apparatus for skin fluorescence according to an embodiment of the present invention;

FIGS. 6 through 10 are views illustrating an optical prism and an optical connector in a reflection detection type measurement apparatus for skin fluorescence according to another embodiment of the present invention;

FIG. 11 is a view illustrating a reflection detection type measurement for skin fluorescence according to an embodiment of the present invention, which is configured to include a housing equipped with two light sources and two optical detectors;

FIG. 12 is a plan view illustrating a pyramidal holder in which light sources and optical detectors are installed in a reflection detection pyramidal measurement apparatus for skin fluorescence according to an embodiment of the present invention;

FIGS. 13 through 15 are exploded views illustrating a pyramidal measurement module of a reflection detection pyramidal measurement apparatus for skin fluorescence according to an embodiment of the present invention; and

FIG. 16 is a view illustrating an optical attenuation filter in a reflection detection pyramidal measurement apparatus for skin fluorescence.

Reference numerals set forth in the Drawings includes reference to the following elements as further discussed below:

100: measurement scanner	200: main body
111: first light source	112: second light source
121: first optical detector	122: second optical detector
130: polarizer	131: cross-polarizer
210: mounting part	220: display part
310: light source	320: optical detector
311: first light source	312: second light source
321: first optical detector	322: second optical detector
330: optical prism	340: optical connector
351: polarizer	352: cross polarizer
360: main body	
411: first light source	412: second light source
421: first optical detector	422: second optical detector
430: optical prism	440: optical connector
451: polarizer	452: cross polarizer
511: first light source	512: second light source
513: first optical detector	514: second optical detector
515, 516: polarizer	517, 518: cross polarizer
519, 520: optical filter	
521, 522, 523, 524: side plates	
525: window	526: bottom plate
527: bolt	530: pyramidal holder
531, 532, 533, 534: through-holes	535: opening
536, 537: optical attenuation filter	
T: measurement target (skin)	

It should be understood that the appended drawings are not necessarily to scale, presenting a somewhat simplified representation of various preferred features illustrative of the basic principles of the invention. The specific design features of the present invention as disclosed herein, including, for example, specific dimensions, orientations, locations, and shapes will be determined in part by the particular intended application and use environment.

In the figures, reference numbers refer to the same or equivalent parts of the present invention throughout the several figures of the drawing.

DETAILED DESCRIPTION

Hereinafter reference will now be made in detail to various embodiments of the present invention, examples of which are illustrated in the accompanying drawings and described below. While the invention will be described in conjunction with exemplary embodiments, it will be understood that present description is not intended to limit the invention to those exemplary embodiments. On the contrary, the invention is intended to cover not only the exemplary embodiments, but also various alternatives, modifications, equivalents and other embodiments, which may be included within the spirit and scope of the invention as defined by the appended claims.

The above and other features of the invention are discussed infra.

The present invention relates to a skin fluorescence measurement apparatus for irradiating excitation light on the skin and measuring skin fluorescence generated by the excitation light for the purpose of diagnosis of diseases such as diabetes. Particularly, it provides a reflection detection type measurement apparatus for skin fluorescence, which can exactly measure skin fluorescence detected at a location where reflected light is projected among skin fluorescence scattered and emitted from inside of the skin due to light irradiated on the skin.

For this, a sequential measurement may be performed on a target to be diagnosed and a reference sample, and information obtained from the target may be compared with information obtained by the reference sample to remove an individual deviation that the target has, while a light source and an optical detector may be sequentially turned on/off according to certain conditions required in the above process. Thus,

provided is a reflection detection type measurement apparatus for skin fluorescence that can provide a corrected skin fluorescence value.

Hereinafter, exemplary embodiments of a reflection detection type measurement apparatus for skin fluorescence will be described in detail with reference to the accompanying drawings.

It is necessary to select a skin target for measurement of fluorescence generated on the skin and consider factors that affect the measured fluorescence. The measured fluorescence may depend on light scattering and absorption occurring inside the skin even when specular reflection occurring on the skin surface is removed, as well as fluorescent substances included in the skin. Particularly, it is necessary to correct measured fluorescence values in consideration of influences of light absorption and scattering in the fluorescence wavelength generated in fluorescent substances and the excitation light wavelength irradiated to excite fluorescent substances. Accordingly, the following empirical Equation (1) may be considered to reduce the influence of optical factors on the fluorescent intensity.

$$AF_{corr} = AF/(R_1{}^{k1}R_2{}^{k2}) \tag{1}$$

Here, a corrected fluorescence value AF_{corr} may be obtained by dividing a measured fluorescence value AF by an excitation diffusion reflected light R1 and a diffusion reflected light R2 of emission in the fluorescent wavelength range. The two diffusion reflected light values may be adjusted by exponents k1 and k2 without a degree.

Equation (1) may be used to obtain the corrected skin fluorescence value, and concrete values may be introduced to obtain the corrected skin fluorescence value through an actual test.

$I(\lambda 2, t1)$: Inherent fluorescence (skin fluorescence) signal value of skin tissue

$I(\lambda 1, t1)$: Reflected light signal value of skin tissue in excitation light wavelength

$I(\lambda 2, t2)$: Reflected light signal value of skin tissue in emission light wavelength

k1, k2: Exponents of correction function with respect to excitation light and emission light wavelength

The corrected skin fluorescence value that is newly induced may be expressed as Equation (2).

$$AF_{tissue} = [I(\lambda 2, t1)]/[I(\lambda 1, t1)^{k1} I(\lambda 2, t2)^{k2}]; \ k1, k2 < 1 \tag{2}$$

where AF_{tissue} is a correction signal of an inherent fluorescence of a skin tissue.

The light measurement may be periodically performed at different time intervals t1 and t2. The measurement results may be averaged to increase the accuracy. The measured values may be recorded in a form of time diagram to trace the variation at an appropriate time.

Meanwhile, correction of deviations depending on equipment and correction measurement for a comparison between the results obtained from different samples may be needed. Accordingly, in the present invention, the equal measurement may be performed by introducing reference samples together with the measurement of the target skin tissue. In order to increase the measurement accuracy, the fluorescence intensity $I_0(\lambda 2, t1)$ and the reflected light signal values $I_0(\lambda 1, t1)$ and $I_0(\lambda 2, t2)$ in the excitation light and the emission light may be similar to the optical characteristics of the skin.

The signal values generated in the measurement process of the introduced reference sample may be expressed as follows similarly to those for the target skin tissue.

$I_0(\lambda 2, t1)$: Inherent fluorescence signal value of reference sample.

$I_0(\lambda 1, t1)$: Reflected light signal value of reference sample in excitation light wavelength.

$I_0(\lambda 2, t2)$: Reflected light signal value of reference sample in emission light wavelength.

The signals obtained from the reference samples may be processed by Equation (3) similarly to Equation (2).

$$AF_{reference}=[I_0(\lambda 2, t1)]/[I_0(\lambda 1, t1)^{k1}I_0(\lambda 2, t2)^{k2}] \quad (3)$$

A result obtained by dividing AF_{tissue} by $AF_{reference}$ may be normalized, and a finally corrected inherent fluorescence value may be expressed as Equation (4).

$$AF_{corr}=K(AF_{tissue}/AF_{reference}) \quad (4)$$

$$AF_{corr}=K[I(\lambda 2, t1)/I_0(\lambda 2, t1)]/\{[I(\lambda 1, t1)/I_0(\lambda 1, t1)]^{k1}[I(\lambda 2, t2)/I_0(\lambda 2, t2)]\}^{k2} \quad (5)$$

where K is a ratio coefficient that considers the features of the used reference samples.

Equation (5) may be simplified as Equation (6)

$$AF_{corr}=K[I(\lambda 2, t1)/I_0(\lambda 2, t1)]/\{[R(\lambda 1)]^{k1}[R(\lambda 2)]\}^{k2} \quad (6)$$

$R(\lambda 1)=I(\lambda 1, t1)/I_0(\lambda 1, t1)$: Diffuse reflection coefficient in excitation wavelength.

$R(\lambda 2)=I(\lambda 2, t2)/I_0(\lambda 2, t2)$: Diffuse reflection coefficient in emission wavelength.

Thus, regarding the reflection detection type measurement apparatus of skin fluorescence according to the embodiment of the present invention, the corrected skin fluorescence values may be calculated by the above operation processes.

In this regard, the principle proposed for the measurement will be described in detail with reference to FIG. 1.

FIG. 1 is a graph illustrating the intensities of light inputted from a light source and light detected by an optical detector which are shown according to time to explain the measurement principle of a reflection detection type measurement apparatus for skin fluorescence according to an embodiment of the present invention. As shown in FIG. 1, in the reflection detection type measurement apparatus for skin fluorescence, the measurement may be successively performed under a first condition in which light corresponding to a wavelength range (first wavelength $\lambda 1$) of excitation light is irradiated as an input, and a second condition in which light corresponding to a wavelength range (second wavelength $\lambda 2$) of skin fluorescence generated by the excitation light is irradiated while being separated from each other in time. The wavelength range of the irradiation light corresponding to the first and second conditions may be selectively configured according to the skin fluorescence to be detected. For example, considering that the skin fluorescence is detected with respect to AGE in an exemplary embodiment, light with the first wave length of 370 nm±20 nm may be used as the excitation light for the fluorescence excitation under the first condition, and light with the second wave length of 440 nm±20 nm corresponding to the wavelength of the skin fluorescence with respect to AGE may be selectively used under the second condition.

The measurement may be performed using a measurement scanner 100 including light sources for emitting two different wavelengths of light and an optical detector for detecting two different wavelengths of light. The measurement may be performed by contacting the measurement scanner 100 with the skin tissue corresponding to a measurement target in the diagnosis observance process or the reference sample in the correction process.

In regard to the measurement process, FIG. 1A shows an operating time diagram showing the respective light sources with respect to two different wavelengths operate while being separated from each other in time. In this case, light $\Phi(\lambda 1, t1)$ irradiated from a first light source 111 that is an excitation

light source may be configured to exist in a different time from light $\Phi(\lambda 2, t2)$ from a second light source 112 that is a reference light source of different wavelength.

FIG. 1B shows an operating time diagram with respect to two optical detectors. In the same time while light $\Phi(\lambda 1, t1)$ is being radiated from the first light source 111, two signals may be generated with respect to the excited skin fluorescence and the reflected light. Two signals generated in the excitation light wavelength may be a reflected light signal $I(\lambda 1, t1)$ and an excited fluorescence signal $I(\lambda 2, t1)$.

Meanwhile, only a single signal may be generated in a time when light $\Phi(\lambda 2, t2)$ is irradiated from the second light source 112. The signal generated by the second light source 112 may be only a reflected light signal $I(\lambda 2, t2)$ in the wavelength range of the irradiated light.

As shown in FIG. 1, in the reflection detection type measurement apparatus for skin fluorescence, the light irradiation of the first light source 111 and the light irradiation of the second light source 112 may be sequentially performed on the measurement target T while being separated from each other in time. In this case, the signals detected from the optical detector may be collected upon each light irradiation, and then may be calculated using the above equations to output the corrected skin fluorescence value.

FIG. 2 is a view illustrating a reflection detection type measurement apparatus for skin fluorescence according to an embodiment of the present invention, which is implemented by the measurement principle described above.

As shown in FIG. 2, the reflection detection type measurement apparatus for skin fluorescence may include a measurement scanner 100 that irradiates excitation light on the skin and detects skin fluorescence, and a main body 200 that is connected to the measurement scanner 100 and analyzes data detected by the measurement scanner 100 to display the data.

However, it will be only an exemplary configuration that the measurement scanner 100 and the main body 200 are configured to be separated from each other. Accordingly, if necessary, the reflection detection type measurement apparatus for skin fluorescence may be manufactured in a form of a single sensor without a separate main body, or may further include other components connected thereto.

The reflection detection type measurement apparatus for skin fluorescence may be configured to include a light source and an optical detector to irradiate light on a target to be measured and detect skin fluorescence generated by the irradiated light.

Particularly, in order to provide exact skin fluorescence values by correcting the detected skin fluorescence values, the reflection detection type measurement apparatus for skin fluorescence may include two light sources that irradiate different wavelengths of light and two optical detectors that can detect different wavelengths of reflected light and skin fluorescence generated by the two irradiation lights.

Specifically, the two light sources may include the first light source 111 that emits light corresponding to the wavelength range (first wavelength $\lambda 1$) of the excitation light and the second light source 112 that emits light corresponding to the wavelength range (second wavelength $\lambda 2$) of skin fluorescence generated by the excitation light. The two optical detectors may include a first optical detector 121 for detecting reflected light $\lambda 1$ with respect to the excitation light from the first light source 111 and a second optical detector 122 for detecting reflected light $\lambda 2$ with respect to the emission light from the second light source 112 and the skin fluorescence $\lambda 2$ generated by the excitation light.

Therefore, the two light sources and optical detectors may be configured to simultaneously detect the reflected light and

the skin fluorescence. Preferably, the two light sources and optical detectors may be disposed at one end of the measurement scanner **100**, and may be close to each other so as to irradiate light on the measurement target T and detect the reflected light.

In an exemplary embodiment of the present invention, in order to detect the skin fluorescence with respect to AGE, light with the first wavelength of 370 nm±20 nm may be used as excitation light for fluorescence excitation, and light with the second wavelength of 440 nm±20 nm corresponding to the wavelength of the skin fluorescence with respect to AGE may be used as the emission light.

In this case, the first light source **111** may include a light emitting diode that irradiates light of the first wavelength range, 370 nm±20 nm. The second light source **112** may include a light emitting diode that irradiates light of the second wavelength range, 440 nm±20 nm. Also, the first optical detector **121** may include a photodiode that detects light of the first wavelength range, and the second optical detector **122** may include a photodiode that detects light of the second wavelength range.

Although not shown in FIG. **2**, the reflection detection type measurement apparatus for skin fluorescence may further include a light source switching control unit for controlling turning on/off of the first and second light sources **111** and **112**. More preferably, the reflection detection type measurement apparatus for skin fluorescence may further include an optical detector switching control unit for controlling turning on/off of the first and second optical detectors **121** and **122**.

The light source switching control unit and the optical detector switching control unit may control switching such that the light sources and the optical detectors can exactly operate according to the detection conditions of the skin fluorescence and the reflected light in order to exactly calculate the skin fluorescence values.

The light source switching control unit may be configured to turn on or off the light sources according to the light irradiation conditions of the reflection detection type measurement apparatus for skin fluorescence. For example, under the first condition in which excitation light λ1 is irradiated on the measurement target, the second light source **112** may be turned off and the first light source **111** may be turned on, controlling switching of the light sources such that only the first light source **111** irradiates light of a first wavelength range. On the other hand, under the second condition in which emission light λ2 of a different wavelength range from the excitation light is irradiated on the measurement target, the first light source **111** may be turned off and the second light source **112** may be turned on such that light of a second wavelength range is irradiated from only the second ling source **112**.

Similarly, the optical detector switching control unit may be configured to control turning on/off of the optical detectors according to the measurement conditions. The optical detector switching control unit may be configured to power on/off the optical detectors for detecting light of a wavelength range to be detected under a current measurement condition.

Particularly, since an optical signal with respect to the second wavelength may need to be detected under both first condition in which the excitation light of the first wavelength range is irradiated and second condition in which the emission light of the second wavelength range is irradiated, the second optical detector **122** for detecting light with respect to the second wavelength may be maintained turned on.

In this case, the switching control may be sequentially performed on the light sources for a certain time during the whole measurement process including the first condition and

the second condition. In regard to the period of switching with respect to each light source, the switching control may be performed at a high frequency of about 10 Hz to about 100 Hz such that the variation of the diffusion reflectance due to the blood flow does not affect the measurement by considering the pulse rate of the human body.

As the measurement scanner **100** of the reflection detection type measurement apparatus for skin fluorescence is manufactured in a hand-grippable form, such high-speed switching may achieve measurement on the substantially same target spot even when the measurement scanner **100** is moved by a scanning method in which the skin fluorescence is continuously measured while the scanner is moving.

Although not shown in FIG. **2**, the reflection detection type measurement apparatus for skin fluorescence may include an optical filter selectively disposed at the front of the light source and the optical detector. Preferably, in order to prevent the detection of the skin fluorescence with a relatively lower light intensity from becoming difficult due to specular reflection of irradiated light on the skin surface, a pair of polarizers **130** and a pair of cross-polarizers **131** may be disposed between corresponding light sources and optical detectors.

The polarizers and the cross-polarizers may need to be disposed at mutually-crossing locations on a pair of the first light source **111** and the first optical detector **121** and a pair of the second light source **112** and the second optical detector **122**, respectively.

Meanwhile, the reflection detection type measurement apparatus for skin fluorescence may be configured to include the main body **200** that is configured to be connectable to the measurement scanner **100** including two light sources and two optical detectors. The main body **200** may be configured to include an operation part that calculates the value of corrected skin fluorescence from data measured by the measurement scanner **100**.

The main body **200** may be configured to be optically, electrically and mechanically connectable to the measurement scanner **100**.

Specifically, the main body **200** may include a mounting part **210** with a shape matching the shape of a measurement terminal of the measurement scanner **100** such that the measurement scanner **100** can be mechanically mounted onto the main body **200**. The measurement scanner **100** may be fixedly mounted into the mounting part **210** through mechanical coupling.

In an exemplary embodiment of the present invention, the first and second light sources **111** and **112** and the first and second optical detectors **121** and **122** may be configured to be disposed on one end portion of the measurement scanner **100**, while the mounting part **210** may be configured to have an aperture structure formed in a shape corresponding to the shape of one end portion of the measurement scanner **100**, allowing the light sources and the optical detectors to be fixed in the mounting part **210** while facing each other.

Preferably, as the measurement scanner **100** is mounted onto the main body **200**, the main body **200** may be configured to be electrically connectable to the measurement scanner **100**, allowing the measurement scanner **100** to irradiate light on the measurement target T and acquire data about the detected skin fluorescence and the reflected light. More preferably, a reference sample for comparison with the measurement target T may be disposed over the mounting part **210** of the main body **200**, and the light sources and the optical detectors of the measurement scanner **100** may be configured to be optically connected to the reference sample when the measurement scanner **100** is seated on the mounting part **210** of the main body. In this case, the reference sample may be

selected so as to have the optical characteristics of the diffuse reflection and fluorescence similar to the human body's tissue that is measured.

Therefore, when the measurement scanner **100** is mounted onto the mounting part **210** of the main body **200** to be electrically and optically connected, the measurement scanner **100** may perform light irradiation and light detection processes, which have been performed on the measurement target T, on the reference sample. The measured data of the measurement target and the reference sample may be transmitted to the operation part of the main body **200**.

The operation part may calculate corrected skin fluorescence values regarding the actual measurement target using data about the fluorescence signals and the reflected light signals that are received. The calculation result may be displayed via the display part **220** on the main body **200**.

The above sequential measurement may be repeated. In order to perform an operation process in which correction is performed according to the results of the repeated measurement, all measured data may be stored in the measurement scanner **100** via a memory. Preferably, the measurement results may be stored in a form of time diagram to trace the variation of the measurement results.

A charging terminal may be disposed in the mounting part **210** on the main body **200** to charge the measurement scanner **100**. The charging terminal may be configured to perform charging when the measurement scanner **100** is mechanically coupled to the mounting part **210**.

If necessary, the measurement scanner **100** may be configured to be connected to the main body **200** through Bluetooth.

An exemplary arrangement of the light sources and the optical detectors in the reflection detection type measurement apparatus for skin fluorescence is shown in FIGS. **3** and **4**.

FIG. **3** is a view illustrating an exemplary arrangement of light sources and optical detectors when there is no gap between the light sources/optical detectors and the measurement target. FIG. **4** is a view illustrating an exemplary arrangement of light sources and optical detectors when there is a gap between the light sources/optical detectors and the measurement target.

As shown in FIG. **3**, the light sources and the optical detectors may be disposed parallel to each other and perpendicular to the measurement target, respectively. In order to form an optimum detection region, the first light source **111** and the second light source **112** may be disposed at the outer sides, respectively, and the first optical detector **121** and the second optical detector **122** may be disposed between the first and second light sources **111** and **112**.

As shown in FIG. **4**, when a certain gap exists between the light sources/optical detectors and the measurement target, the light sources and the optical detectors may be obliquely disposed to be inclined with respect to each other, and may be configured to form light irradiation paths and light detection paths such that the light sources can irradiate light on the same region of the measurement target and the optical detectors can detect light generated in the same region, respectively. Preferably, the light source and the optical detector corresponding to each other may be disposed to be inclined at an angle of about 45 degrees with respect to each other. For example, when a light source vertically irradiates light on the skin surface, an optical detector may be disposed to be inclined at an angle of about 45 degrees with respect to the light source, thereby reducing an influence of specular reflection. An angle between the first and second light sources **111** and **112** and the first and second optical detectors **121** and **122** may be minimized according to the structure of equipment. More preferably, the influence of the specular reflection may be mini-

mized by disposing a pair of cross-polarizers **130** between corresponding light source and optical detector at the front of the light sources and the optical detectors together with optical filters to remove the specular reflection light.

In this case, the first light source **111**, the second light source **112**, the first optical detector **121**, and the second optical detector **122** may be configured to be connected to the end of the measurement target side of the measurement scanner **100** via a light guide, respectively. A transparent protection film such as a glass plate may be disposed on the contact surface between the skin and the sensor to protect the measurement scanner **100** from foreign substances such as external moisture.

Hereinafter, a test example of the light irradiation, the light detection, and the operation process performed by the reflection detection type measurement apparatus for skin fluorescence configured as above will be described as follows.

EXAMPLE 1

It is necessary to perform measurement on a measurement target and a reference sample, two targets that are introduced to obtain a corrected fluorescence value. Light measurement is performed on the human body's skin that is the measurement target among the two targets.

For diagnosis, the measurement is performed by a light source and an optical detector that contact or get close to the measurement target on the upper arm of a subject. A measurement scanner moves along the skin surface to scan the target part of about 5 cm2 to about 19 cm2.

Before the measurement, all light sources are turned off, and then level evaluation of a dark signal is performed to automatically compensate for light leaking from the outside.

A light module sequentially generates first light source illumination light $\Phi(\lambda 1, t1)$ with a wavelength $\lambda 1$ and second light source illumination light $\Phi(\lambda 2, t2)$ with a wavelength $\lambda 2$ at different time intervals t1 and t2, respectively.

During the whole measurement process, light generated by two light sources is sequentially radiated at time intervals t1 and t2 while switching on/off is being repeated at a period of about 50 Hz.

Next, light irradiated from the light sources is detected by the optical detectors to be converted into electrical signals.

The first light source illumination light $\Phi(\lambda 1, t1)$ of a near-ultraviolet spectrum range (near 370 nm) excites the fluorescence of a target to form a corresponding signal $I(\lambda 2, t1)$ by the optical detector, and forms a signal $I(\lambda 1, t1)$ proportional to excitation reflection light diffuse-reflected by the skin that is the measurement target.

The second light source illumination light $\Phi(\lambda 2, t2)$ of a blue spectrum range (near 440 nm) corresponds to the maximum value of the inherent fluorescence generated in AGE and NADH, and forms a signal $I(\lambda 2, t2)$ proportional to the emission light that is diffuse-reflected by the target skin.

The above measurement is repeatedly and periodically performed at different time intervals t1 and t2, and the measurement results are averaged and stored.

The same measurement processes are performed on the reference sample, and data calculated in each process is processed in an operation part to calculate a corrected skin fluorescence value.

A time diagram regarding the actuation of the light sources having two wavelengths in the above test example may be shown as Table 1 below.

TABLE 1

| | 1st Cycle | | | | 2nd Cycle | | | |
	Dark	F440/R365	Dark	R440	Dark	F440/R365	Dark	R440	Dark
LED365	OFF	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF
LED440	OFF	OFF	OFF	ON	OFF	OFF	OFF	ON	OFF
PD365	ON	ON	ON	OFF	ON	ON	ON	OFF	ON
PD440	ON	ON	ON	ON	ON	ON	ON	ON	ON

In this test example, the respective cycle time is configured to be about 20 ms. Also, the measurement target scanning time is calculated as about 2 seconds, and 100 measurement cycles are performed.

Data measured in this test example is stored and preserved in an internal memory of the measurement scanner. When the measurement scanner is placed on the mounting part of the main body, the detection information is automatically moved to the operation part of the main body to undergo an operation according to function conversion and be statistically processed, and the measurement results are displayed.

Meanwhile, the present invention proposes a structure in which an optical prism and an optical connector are disposed on an optical path such that the optical transmission and detection efficiencies can be improved.

FIG. 5 illustrates a reflection detection type measurement apparatus for skin fluorescence according to an embodiment of the present invention, compared with a typical reflection detection type measurement apparatus for skin fluorescence. FIG. 5A illustrates the optical irradiation and the optical detection without an optical prism and an optical connection. FIG. 5B illustrates the optical irradiation and the optical detection with an optical prism and an optical connection.

In a case where the optical irradiation and the optical detection are performed without an optical prism and an optical connector as shown in FIG. 5A, excitation light may be irradiated from a light source 310, and then an optical detector 320 may detect fluorescence caused by the excitation light.

In this case, as shown in FIG. 5A, since the light source 310 such as a Light Emitting Diode (LED) used as an excitation light source irradiates light with a wide divergence angle, an optical loss may occur on a measurement target, and scattering of fluorescence from the skin on which light is irradiated may cause a loss of the quantity of light detected by the optical detector 320.

Since the skin fluorescence detected is significantly smaller than other excitation light or reflected light thereof, the optical loss may considerably reduce the accuracy of the measurement and the reliability of the diagnosis even when the optical loss is slight.

On the other hand, in order to prevent the optical loss, a reflection detection type measurement apparatus for skin fluorescence including an optical prism is proposed as shown in FIG. 5B.

Referring to FIG. 5B, the excitation light irradiated from the light source 310 may be concentrated by the optical prism 330, and the optical uniformity of a skin part that is the measurement target can be improved.

Specifically, the optical prism 330 may have two upper inclination surfaces 331 and 332 that are adjacent to the light source 310 and the optical detector 320, respectively, and a lower surface 333 that is adjacent to the skin. Excitation light irradiated from the upper inclination surface 331 adjacent to the light source 310 with a wide divergent angle may be totally reflected from the inside of the upper inclination surface 332 of the optical prism 330 at the side of the optical

detector 320 may be maximally concentrated on the skin, thereby reducing the non-uniformity of the light source, i.e., the characteristics in which the optical intensity becomes smaller at the outer side of the optical axis than at the center of the optical axis and thus achieving improved optical uniformity.

Also, the optical prism 330 may serve to concentrate a secondary light generated by light transmitted to the skin tissue part on the optical detector 320. Accordingly, in the reflection detection type measurement apparatus for skin fluorescence, an optical signal can be improved, and a measurement error can be reduced. Thus, an optical measurement can be performed on a wide skin part without a scanning method of an optical sensor.

The reflection detection type measurement apparatus for skin fluorescence according to the embodiment of the present invention may be configured to include an optical connector 340 for reducing a specular reflection component reflected by the surface of the skin that is the measurement target and allowing light to effectively penetrate into the skin.

The optical connector 340 may be configured to locate between the undersurface 333 of the optical prism 330 adjacent to the skin that is the measurement target and the surface of the skin, and may contact the undersurface 333 of the optical prism and the surface of the skin, respectively.

The optical connector 340 may contact the undersurface 333 of the optical prism 330 and the surface of the skin to serve as a connection layer for allowing a smooth optical contact with an appropriate refractive index at the boundaries thereof. The optical connector 340 may prevent the specular reflection from the surface of the skin, and may allow light to effectively penetrate into the skin.

The optical connector 340 may have a certain refractive index between two media to prevent a light leakage that may occur between the two media due to the refraction and scattering of the excitation light between the optical prism 330 and the skin tissue, and may serve to fill uneven portions such as fine unevenness of the skin tissue.

The optical connector 340 may be formed of an elastic material or a liquid material such as water or oil-immersion. The optical connector 340 may be formed of a material having a refractive index similar to those of the optical prism 330 and the skin.

Due to the optical connector 340, the total internal reflection of the irradiated light may not occur at the boundaries between the prism and the skin tissue, and the penetration efficiency of light emitting from the light source into the skin can be significantly improved.

Accordingly, the reflection detection type measurement apparatus for skin fluorescence including the optical prism 330 and the optical connector 340 can improve the optical concentration and the optical uniformity, and can significantly reduce the specular reflection component of light irradiated from the light source by the surface of the skin.

EXAMPLE 2

A reflection detection type measurement apparatus for skin fluorescence including an optical prism and an optical con-

nector was manufactured. Also, as a comparative example, an apparatus configured such that a light source and an optical detector are located similarly to those of the reflection detection type measurement apparatus and optical irradiation and optical detection are performed without the optical prism and the optical connector was manufactured.

In this test example, a UV LED (No 33, Nichia) emitting light of about 365 nm was used as the light source, and an optical fiber spectrometer (AVaspec-2048) was used as the optical detector. Also, an optical photodiode may also be used as the optical detector. A commercialized model (Right Angle Prism, Uncoated, 20 mm, Edmund Optics) was used as the optical prism.

In this test example, water was used as the optical connector, which was interposed between the optical prism and the surface of the skin that is the measurement target.

A specular reflection component of light irradiated from the light source in the reflection detection type measurement apparatus of the test example was measured, and a specular reflection component in the apparatus of the comparative example was also measured.

In the measurement results from the test example and the comparative example, the specular reflection component of the test example was measured to be reduced by about ten times or more compared to that of the comparative example.

FIG. 6 illustrates a reflection detection type measurement apparatus for skin fluorescence including two light sources 311 and 312 and two optical detectors 321 and 322, which is configured as shown in the test examples 1 and 2. Like in FIG. 5, an optical prism 330 and an optical connector 340 may be interposed between the two light sources 311 and 312 and the two optical detectors 321 and 322 and the skin T that is the measurement target.

In this embodiment, the optical prism 330 may have two upper inclination surfaces 331 and 332 adjacent to the light source and the optical detector, respectively, and a lower surface 333 adjacent to the skin. A triangular prism 330 333 having a triangular section may be used like in FIG. 5. Preferably, the two light sources 311 and 312 may be disposed on the upper inclination surface 331 of the triangular prism 330, and the two optical detectors 321 and 322 may be disposed on the upper inclination surface 332 of the triangular prism, allowing the undersurface 333 of the prism 330 to contact the skin.

In this case, when the two different light sources 311 and 312 are disposed on the upper inclination surface 331, the optical axes of the two light sources 311 and 312 may differ from each other. Accordingly, the regions of the skin T on which the light is irradiated may differ from each other.

However, since the light source is connected to the measurement target T through the optical prism 330, uniform light in which the difference between the optical axes can be corrected by the optical reflection inside the optical prism 330 can be obtained.

Also, a polarizer 351 may be disposed between the light sources 311 and 312 and the optical prism 330, and a cross polarizer 352 may be disposed between the optical detectors 321 and 322 and the optical prism 330. As shown in FIG. 6, the polarizer 351 may be disposed on the upper inclination surface of the optical prism 330 under the first and second light sources 311 and 312, and the cross polarizer 352 may be disposed on the other upper inclination surface of the optical prism 330 under the first and second optical detectors 321 and 322.

As shown in FIG. 6, the optical connector 340 may be disposed between the skin T that is the measurement target and the undersurface 333 of the optical prism 330. The optical

connector 340 may contact the undersurface 333 of the optical prism 330 and the surface of the skin T, respectively, allowing smooth optical contact with an appropriate refractive index at the boundaries thereof.

Accordingly, the specular reflection component generated from the surface of the skin T by the optical connector 340 can be reduced, and light partially reflected by a difference of the refractive index between the surface of the skin T and the optical connector 340 can be additionally inhibited by the cross polarizer 352 disposed at the front of the optical detectors 321 and 322.

The reflection detection type measurement apparatus for skin fluorescence may be configured to be connected to a main body 360 that includes a light source switching controller for controlling turning on/off of the first and second light source 311 and 312 and an operator for calculating a correction value of a skin fluorescence signal from a detected fluorescence signal and a reflected light signal.

As described in FIG. 2, in the reflection detection type measurement apparatus for skin fluorescence according to this embodiment, the light source 311 and 312 and the optical detectors 321 and 322 may also be disposed at one end of a measurement scanner, and a corrected skin fluorescence value can be obtained by an operation process similar to that of FIG. 2 except that the light irradiation is performed through the optical prism disposed between the light source and the measurement target.

FIG. 7 illustrates a reflection detection type measurement apparatus for skin fluorescence according to another embodiment of the present invention. As shown in FIG. 7, the reflection detection type measurement apparatus may include an optical prism 430 of a trapezoidal section having an upper surface 431, a lower surface 432, and two inclination surfaces 433 and 434, and an optical connector 440 interposed between the lower surface 432 and the skin T. Two light sources 411 and 412 may be disposed over the two inclination surface 433 and 434, respectively, and two optical detectors 421 and 422 may be disposed over the upper surface 431 of the optical prism 430.

Unlike FIG. 6, the optical prism 430 may have a trapezoidal section, which further has the upper surface in addition to the two upper inclination surfaces and the undersurface.

Specifically, the optical prism 430 may be formed to have a trapezoidal shape in which the upper surface 431 is further included in addition to the two upper inclination surfaces 433 and 434 adjacent to the light source and the optical detector, respectively, and the lower surface 432 adjacent to the skin T. Also, the light sources 411 and 412 and the optical detectors 421 and 422 may be disposed over the two upper inclination surfaces 433 and 434 and the upper surface 431, respectively.

In this embodiment, the first light source 411 and the second light source 412 irradiating light having a wavelength different from the first light source 411 may be disposed over the upper inclination surfaces 433 and 434 of the optical prism 430, respectively. Also, the first and second optical detectors 421 and 422 may be disposed over the upper surface 431 connected to the two upper inclination surfaces 433 and 434 to detect light having different wavelengths regarding a fluorescence signal and a reflected light signal.

Similarly to FIG. 6, a polarizer 451 and a cross polarizer 452 may be disposed between the light source 411 and 412 or the optical detectors 421 and 422 and the optical prism 430 to remove reflected light, respectively. As shown in FIG. 7, the polarizer 451 may be disposed between the first and second light source 411 and 412 and the upper inclination surfaces 433 and 434 of the optical prism 430, and the cross polarizer

452 may be disposed between the first and second optical detector 421 and 422 and the upper inclination surface 431 of the optical prism 430.

Also, an optical connector 440 may be disposed between the undersurface 432 of the optical prism 430 and the skin T that is the measurement target. The optical connector 440 may contact the undersurface 432 of the optical prism 430 and the surface of the skin T, respectively.

FIGS. 8 and 9 illustrate reflection detection type measurement apparatuses for skin fluorescence according to other embodiments of the present invention. In these embodiments, optical prisms having trapezoidal sections may be used similarly to that of FIG. 7, but the arrangement of light sources and optical detectors is different from each other.

In FIG. 8, two light sources 411 and 412 may be disposed over the upper surface 431 of an optical prism 430, and two optical detectors 421 and 422 may be disposed over two upper inclination surfaces 433 and 434, respectively.

In FIG. 9, two light sources 411 and 412 may be disposed over one upper inclination surface 433 of an optical prism 430, and two optical detectors 421 and 422 may be disposed over the other upper inclination surface 434 of the optical prism 430.

FIG. 10 illustrates a reflection detection type measurement apparatus for skin fluorescence according to another embodiment of the present invention. In this embodiment, an optical prism 430 of a trapezoidal section having four upper inclination surfaces 433, 434, 435 and 436 may be disposed. Here, two light sources 411 and 412 and two optical detectors 421 and 422 may be disposed over the upper inclination surfaces 433, 434, 435 and 436 such that the two light sources 411 and 412 and the two optical detectors 421 and 422 face each other, respectively.

As shown in FIG. 10, the first light source 411 and the second light source 412 may be selectively disposed over the two upper inclination surfaces 435 and 436, and the first optical detector 421 and the second optical detector 422 may be selectively disposed over the other two upper inclination surfaces 433 and 434.

The first and second light sources 411 and 412 may be disposed over the two upper inclination surfaces 435 and 436 that are opposite to each other, and the first optical detector 421 and the second optical detector 422 may be disposed over the two upper inclination surfaces 433 and 434 that are opposite to each other.

In this case, the light sources 411 and 412 and the optical detectors 421 and 422 may be disposed orthogonally to each other. Such the orthogonal arrangement may reduce a specular reflection component.

A reflection detection pyramidal measurement apparatus for skin fluorescence according to an embodiment of the present invention may be configured to have a structure in which two light sources 111 and 112 and two optical detectors 121 and 122 disposed at four sides of a pyramidal holder, respectively. The measurement principle of the pyramidal measurement apparatus for skin fluorescence may be substantially similar to the case where the light source and the optical detector are disposed side by side as shown in FIG. 1.

In this regard, FIG. 11 illustrates a pyramidal holder equipped with two light sources and two optical detectors to implement the above measurement principle. FIG. 12 is a plan view illustrating the pyramidal holder.

As shown in FIG. 11, a reflection detection type measurement apparatus for skin fluorescence according to an embodiment of the present invention may include a measurement scanner 100 that can irradiate excitation light and detect skin

fluorescence and a main body 200 that is connected to the scanner 100 to analyze information detected from the scanner and display the information.

However, this configuration in which the measurement scanner 100 and the main body 200 are separately provided is merely one of exemplary embodiments of the present invention, Accordingly, a separate main body may not be provided according to a need, but may be manufactured in a single sensor type, and other components may be additionally connected thereto.

The light source and the optical detector may be disposed on a pyramidal measurement module 500 disposed on one end of the measurement scanner 100.

That is, the two light sources and the two optical detectors may be mounted in the four side surfaces of the pyramidal holder to form the pyramidal measurement module 500 disposed on one end of the measurement scanner 100 as shown in FIG. 11.

More specifically, as shown in FIG. 12, the pyramidal holder constituting the pyramidal measurement module 500 may have four through-holes in four side surfaces thereof, and the four through-holes may receive the light sources L1 and L2 and the optical detectors D1 and D2, respectively.

In this case, as shown in FIG. 12, the light sources L1 and L2 may be mounted in two side surfaces of the pyramidal holder opposite to each other, respectively, and the optical detectors D1 and D2 are mounted in the other two side surfaces of the pyramidal holder opposite to each other, respectively.

In this arrangement, when considering the irradiation angle of light and the main optical path of the reflection light according thereto, the direct inflow of reflection light to the optical detector may reduce.

Also, an optical filter may be selectively disposed at the light source and the optical detector in the reflection detection type measurement apparatus for skin fluorescence, and a polarizer and a cross polarizer may be disposed to interrupt light irradiated from the light source from being incident to the optical detector by specular reflection.

Accordingly, the polarizers and the cross polarizers may be disposed at mutually-crossing locations on a pair of the first light source and the first optical detector and a pair of the second light source and the second optical detector, respectively.

However, the purpose of disposing the polarizer and the cross polarizer is to facilitate the detection of skin fluorescence with a relatively low light intensity compared to light by specular reflection, whereas the intensity of the light source and the detection of the fluorescence may be reduced by the polarizer and the cross polarizer. In this case, since there may occur a difficulty of fluorescence measurement, an appropriate design is needed.

In this regard, since the polarizer and the cross polarizer are not essential components for the reduction of the specular reflection, and in the reflection detection type measurement apparatus for skin fluorescence, the light source and the optical detector are mutually arranged at an angle of 90 degrees through a pyramidal measurement module, the specular reflection effect can be fundamentally reduced through the structural arrangement.

FIGS. 13 through 15 illustrate the concrete configuration of a pyramidal measurement module of a reflection detection pyramidal measurement apparatus for skin fluorescence according to an embodiment of the present invention.

FIG. 13 is an exploded perspective view of a pyramidal measurement module according to an embodiment of the

present invention. FIGS. **14** and **15** are side views when viewed from arrows "A" and "B" of FIG. **13**.

As shown in FIG. **13**, the pyramidal module **500** of the reflection detection pyramidal measurement apparatus for skin fluorescence may include two light sources and two optical detectors, and a pyramidal holder **530** equipped with the light sources and the optical detectors.

The pyramidal holder **530** may have a pyramidal shape having four side surfaces and one bottom surface. The light sources and the optical detectors may be installed in the side surfaces of the pyramidal holder **530**, respectively.

More specifically, four through-holes **531**, **532**, **533** and **534** may be formed in the side surface of the pyramidal holder **530** to receive the light sources and the optical detectors. That is, as shown in FIG. **12**, the first through-hole **531** formed in one side surface of the pyramidal hold **530** may receive the first light source **511**, and the second through-hole **532** opposite thereto may receive the second light source **512**. Also, the third through-hole **533** and the fourth through-hole **534** may be formed in the two side surfaces between the two side surfaces having the first through-hole **531** and the second through-hole **532**, respectively. The third through-hole **533** may receive the first optical detector **513** and the fourth through-hole **534** may receive the second optical detector **514**.

In this case, the two light sources may be disposed so as to obliquely irradiate light from the side surfaces of the pyramidal holder **530** to a measurement target. The two optical detectors may also be obliquely disposed on the two side surfaces opposite to each other.

Also, optical irradiation paths and optical detection paths may be allowed to be formed such that the light sources and the optical detectors can irradiate light on the same region of the measurement target and detect light generated from the same region. Preferably, light sources and the optical detectors opposite to each other may be obliquely disposed at an angle of about 45 degrees with respect to the bottom surface of the pyramidal holder **530** adjacent to the measurement target, thereby significantly reducing an influence of the specular reflection.

Also, a pair of polarizers **515** and **516** and cross polarizers **517** and **518** may be disposed in the through-holes **531**, **532**, **533** and **534** together with optical filters **519** and **520** to minimize the influence of the specular reflection.

The polarizers **515** and **516**, the cross polarizers **517** and **518**, and the optical filters **519** and **520** may be disposed in the through-holes **531**, **532**, **533** and **534** so as to be adjacent to the bottom surface of the pyramidal holder **530** at the inner side of the light sources and the optical detectors.

The through-holes **531**, **532**, **533** and **534** formed in the four side surfaces of the pyramidal holder **530** may communicate with the center, and may be connected to the opening (**535**) of the bottom surface of the pyramidal holder **530**.

A window **525** may be formed in the opening **535** to contact the measurement target, and the window **525** may be selected in consideration of the refractive index of light, and may be formed of a transparent material such as glass.

The window **525** may serve to protect surfaces contacting the skin and the sensor from foreign substances such as external humidity.

Also, a bottom plate **526** may be coupled to the bottom surface of the pyramidal holder **530** via a coupling member such as a bolt **527** to fix the window **525**. The bottom plate **526** may have an opening at the center thereof such that the window **525** can be disposed.

Although not shown, the reflection detection type measurement apparatus for skin fluorescence may further include an

optical connector that reduces a specular reflection component reflected from the skin surface that is a measurement target and allows light to effectively penetrate into the skin.

The optical connector may be configured to locate between the skin surface and the window **525** adjacent to the skin that is the measurement target and contact the window **525** and the skin surface, respectively.

Preferably, a step may be formed between the bottom of the bottom plate **526** and the undersurface of the window **525**. The optical connector may be filled in the portion where the step is formed to form a structure in which the optical connector is contactable with the measurement target.

Accordingly, the optical connector may contact the window **525** and the surface of the skin to serve as a connection layer for enabling a smooth optical contact with an appropriate refractive index at the boundaries thereof. The optical connector may prevent the specular reflection from the surface of the skin, and may allow light to effectively penetrate into the skin.

The optical connector may have a certain refractive index between two media to prevent a light leakage that may occur between two media due to the refraction and scattering of the excitation light between the window **525** and the skin tissue, and may serve to fill uneven portions such as fine unevenness of the skin tissue.

The optical connector may be formed of an elastic material or a liquid material such as water or oil-immersion. Also, the optical connector may be formed of a material having a refractive index similar to those of the window **525** and the skin.

Meanwhile, mounting grooves may be formed in the through-holes **531**, **532**, **533** and **534** of the pyramidal holder **530** such that the light sources, the optical detectors, the polarizers, the cross polarizers, and the optical filters can be seated in the appropriate positions, respectively.

In FIG. **13**, four side plates **521**, **522**, **523** and **524** may be fixedly mounted on the side surfaces of the pyramidal holder **530**, and the light sources and the optical detectors may be mounted on the side plates **521**, **522**, **523** and **524**. That is, the two light sources may be mounted at the inner side of the two side plates among the four side plates **521**, **522**, **523** and **524**, and the two optical detectors may be mounted at the inner side of the other two side plates. The side plates **521**, **522**, **523** and **524** may be fixed on the pyramidal holder **530** by a coupling member such as the bolt **527**.

Similarly to that described above, in FIG. **13**, the optical irradiation from the light source to the measurement target and the optical detection of a fluorescence signal may be performed through the four through-holes **531**, **532**, **533** and **534**.

The side views when viewed from the arrows "A" and "B" of FIG. **13** are shown in FIGS. **14** and **15**. In FIGS. **14** and **15**, the arrangement of the light sources, the optical detectors, the polarizers, and the optical filters are shown.

Hereinafter, an exemplary embodiment of the optical radiation, the optical detection, and the operation process performed by the reflection detection type measurement apparatus for skin fluorescence will be described as follows.

EXAMPLE 3

It is necessary to perform measurement on a measurement target and a reference sample, two targets that are introduced to obtain a corrected fluorescence value. Light measurement is performed on the human body's skin that is the measurement target.

For diagnosis, the measurement is performed by a light source and an optical detector that contact or get close to the measurement target on the upper arm of a subject. A measurement scanner moves and scans along the skin surface to scan the target area of about 5 cm² to about 19 cm². The optical irradiation area of the reflection detection type pyramidal measurement apparatus for skin fluorescence may be about 15 mm in diameter at a time.

Before the measurement, all light sources are turned off, and then level evaluation of a dark signal is performed to automatically compensate for light leaking from the outside.

A light module sequentially generates first light source illumination light $\Phi(\lambda 1, t1)$ with a wavelength $\lambda 1$ and second light source illumination light $\Phi(\lambda 2, t2)$ with a wavelength $\lambda 2$ at different time intervals t1 and t2, respectively.

During the whole measurement process, light generated by two light sources is sequentially radiated at time intervals t1 and t2 while switching on/off is being repeated at a period of about 50 Hz.

Next, light irradiated from the light sources is detected by the optical detectors to be converted into electrical signals.

The first light source illumination light $\Phi(\lambda 1, t1)$ of a near-ultraviolet spectrum range (near 370 nm) excites the fluorescence of a target to form a corresponding signal $I(\lambda 2, t1)$ by the optical detector, and forms a signal $I(\lambda 1, t1)$ proportional to excitation reflection light diffuse-reflected by the skin that is the measurement target. For the test, the first optical detector 513 for measuring a reflection light single value of the target skin tissue in the excitation light wavelength used a 370 nm±20 nm UV bandpass filter as the optical filter 519, and a product #48-630 from Edmund Optics Inc was used.

The second light source illumination light $\Phi(\lambda 2, t2)$ of a blue spectrum range (near 440 nm) corresponds to the maximum value of the inherent fluorescence generated in AGE and NADH, and forms a signal $I(\lambda 2, t2)$ proportional to the emission light that is diffuse-reflected by the target skin. The second optical detector 514 for measuring an inherent fluorescence signal value of the skin tissue used a 440 nm±20 bandpass filter as the optical filter 520, and a product #86-340 from Edmund Optics Inc was used. In the second optical detector 514, a bandpass filter 520 as described above was used to transmit the inherent fluorescence of the skin tissue and interrupt the wavelength of the excitation light, i.e., about 370 nm reflected from the skin tissue.

The above measurement is repeatedly and periodically performed at different time intervals t1 and t2, and the measurement results are averaged and stored.

The same measurement processes are performed on the reference sample, and data calculated in each process is processed in an operation part to calculate a corrected skin fluorescence value.

Meanwhile, in order to obtain the corrected fluorescence signal value of the skin tissue, reflection lights reflected by the measurement target from the first light source 511 and the second light source 512 emitting light having a fluorescence wavelength have to be detected. However, since the intensity of the reflection light is relatively larger than the intensity of the inherent fluorescence emitted from the skin tissue, measurement signal saturation may occur in the first and second optical detectors upon detection of the reflection lights. Accordingly, in order for the optical detectors to simultaneously detect the reflection lights and the inherent fluorescence value without a loss, optical attenuation filters that reduce the amount of light within an irradiation range and do not generate fluorescence in a visible light range may be disposed on a portion of optical paths.

In this regard, FIG. 16 illustrates optical attenuation filters disposed at the front of the second light source and the first optical detector. In this embodiment, optical attenuation filters 536 and 537 may be disposed at the front of the second light source 512 and the first optical detector 513, and the optical attenuation filter may not be disposed at the first light source 511 and the second optical detector 514. That is, as shown in FIG. 16A, the optical attenuation filter 536 may be disposed at the front of the first optical detector 513, and as shown in FIG. 16B, the other optical attenuation filter 537 may be disposed at the front of the second light source.

Thus, the optical attenuation filters 536 and 537 can prevent saturation of the signal output in the first and second optical detectors 513 and 514 by lowering the intensity of the reflection light of the excitation light and the emission light. On the other hand, since the optical attenuation filter is not disposed at the front of the first light source 511 that excites the inherent fluorescence and the second optical detector 514 that detects the fluorescence signal, the fluorescence signal value can be detected without a loss.

As described above, a reflection detection type measurement apparatus for skin fluorescence according to an embodiment of the present invention has the following advantages.

First, since diabetic diseases can be easily diagnosed by evaluating the skin autofluorescence, mass inspection can be performed to find potential diabetic patients. Also, the risk of cardiac-vascular diseases and complications thereof can be predicted.

Second, since the optical concentration and the optical uniformity of light irradiated from a light source are improved, more uniform light can be irradiated on the measurement target.

Third, since the optical efficiency can be improved by efficiently concentrating light from a light source on the skin tissue and minimizing the specular reflection on the surface of the skin tissue, the miniaturization of the apparatus can be achieved.

Fourth, since an error due to specular reflection generated on the skin surface and an error due to light scattering and absorption generated inside the skin can be corrected in measuring skin fluorescence, exact measurement of the skin fluorescence and exact diagnosis of diseases using the skin fluorescence can be achieved.

Fifth, the reflection detection type measurement apparatus for skin fluorescence may include light sources and optical detectors, and may be manufactured in a form of hand-grippable small-size scanner to measure the skin fluorescence. Thus, since a user can scan a diagnostic target by contacting the scanner with the skin of a subject, non-invasive diagnosis can be performed in real-time.

Sixth, since a selective diagnosis is enabled on certain body parts, and the area of the measurement target can be extended to a certain extent through the scanning method, the reliability of a signal and the accuracy of diagnosis can be improved.

The invention has been described in detail with reference to exemplary embodiments thereof. However, it will be appreciated by those skilled in the art that changes may be made in these embodiments without departing from the principles and spirit of the invention, the scope of which is defined in the appended claims and their equivalents.

What is claimed is:

1. A reflection detection type measurement apparatus for measuring skin fluorescence, which is configured to perform light irradiation and light detection on a measurement target, the apparatus comprising:

    a first light source for irradiating a first light on the measurement target;

a second light source for irradiating a second light, which has a same wavelength range as a first reflected light reflected from the measurement target upon irradiating the first light;

a first optical detector for detecting the first reflected light;

a second optical detector for detecting a skin fluorescence generated by the measurement target upon irradiating the first light and a second reflected light reflected from the measurement target upon irradiating the second light;

a light source switching controller for controlling turning on/off of the first light source and the second light source; and

an operator for calculating an intensity skin fluorescence signal by correcting a signal based on the skin fluorescence and the reflected light detected by the first optical detector and the second optical detector.

2. The reflection detection type measurement apparatus of claim 1, further comprising:

an optical prism configured to transmit the excitation light irradiated from the light source to the measurement target and transmit the skin fluorescence signal to the optical detector, wherein the optical prism has a lower surface connected to the measurement target and two or more upper surfaces over which the light source and the optical detector are disposed.

3. The reflection detection type measurement apparatus of claim 2, further comprising an optical connector disposed under the lower surface of the optical prism and contacting the measurement target.

4. The reflection detection type measurement apparatus of claim 3, wherein the optical connector comprises a connection layer formed of a liquid material or an elastic material between the optical prism and the measurement target.

5. The reflection detection type measurement apparatus of claim 2, wherein the optical prism comprises two inclination surfaces and a lower surface adjacent to the measurement target, and is a triangular prism having a triangular section.

6. The reflection detection type measurement apparatus of claim 5, wherein the first light source and the second light source are disposed over one upper inclination surface of the optical prism, and the first optical detector and the second optical detector are disposed over the other upper inclination surface of the optical prism.

7. The reflection detection type measurement apparatus of claim 2, wherein the optical prism comprises two upper inclination surfaces, an upper surface connected to the two upper inclination surfaces, and a lower surface adjacent to the measurement target, and is a trapezoidal prism having a trapezoidal section.

8. The reflection detection type measurement apparatus of claim 7, wherein the first light source and the second light source are disposed over one upper inclination surface of the optical prism, and the first optical detector and the second optical detector are disposed over the other upper inclination surface of the optical prism.

9. The reflection detection type measurement apparatus of claim 7, wherein the first light source and the second light source are disposed over one upper inclination surface and the other upper inclination surface of the optical prism, respectively, and the first optical detector and the second optical detector are disposed over the upper surface of the optical prism.

10. The reflection detection type measurement apparatus of claim 7, wherein the first optical detector and the second optical detector are disposed over one upper inclination surface and the other upper inclination surface of the optical

prism, respectively, and the first light source and the second light source are disposed over the upper surface of the optical prism.

11. The reflection detection type measurement apparatus of claim 2, wherein the optical prism comprises four upper inclination surfaces, an upper surface connected to the four upper inclination surfaces, and a lower surface adjacent to the measurement target, and is a frustum of a quadrangular pyramid having a trapezoidal section.

12. The reflection detection type measurement apparatus of claim 11, wherein the first light source and the second light source are disposed over two upper inclination surfaces of the optical prism, respectively, and the first optical detector and the second optical detector are disposed over the other upper inclination surfaces of the optical prism, respectively.

13. The reflection detection type measurement apparatus of claim 12, wherein the first light source and the second light source are disposed over the two upper inclination surfaces that are opposite to each other, and the first optical detector and the second optical detector are disposed over the other upper inclination surfaces that are opposite to each other.

14. The reflection detection type measurement apparatus of claim 2, further comprising a polarizer and a cross polarizer are disposed between the optical prism and the light source and between the optical prism and the optical detector, respectively.

15. The reflection detection type pyramidal measurement apparatus of claim 1, further comprising a pyramidal holder having four side surfaces and one bottom surface, wherein the first light source, the second light source, the first optical detector, and the second optical detector are disposed in one of the four side surfaces, respectively.

16. The reflection detection type pyramidal measurement apparatus of claim 15, wherein the pyramidal holder has a through-hole in the four side surfaces, respectively, and the through-hole is configured to communicate with an opening formed in the bottom surface of the pyramidal holder to allow the first and second light sources and the first and second optical detectors to perform optical irradiation and optical detection through the through-hole, respectively.

17. The reflection detection type pyramidal measurement apparatus of claim 15, wherein the first light source and the second light source are mounted in two side surfaces of the pyramidal holder opposite to each other, respectively, and the first optical detector and the second optical detector are mounted in the other two side surfaces of the pyramidal holder opposite to each other, respectively.

18. The reflection detection type pyramidal measurement apparatus of claim 16, wherein the pyramidal holder comprises four side plates covering the through-holes in the four side surfaces, and the first light source, the second light source, the first optical detector, and the second optical detector are disposed on the side plates so as to face the through-hole, respectively.

19. The reflection detection type pyramidal measurement apparatus of claim 16, further comprising a polarizer at an inner side of the first and second light sources in the through-hole and a cross polarizer at an inner side of the first and second light sources in the through-hole, respectively.

20. The reflection detection type pyramidal measurement apparatus of claim 19, further comprising an optical filter at an inner side of the optical detector and the cross polarizer in the through-hole.

21. The reflection detection type pyramidal measurement apparatus of claim 16, further comprising a bottom plate disposed under the bottom surface of the pyramidal holder

and having an opening at a center thereof and a window fixed in the opening of the bottom plate.

22. The reflection detection type pyramidal measurement apparatus of claim **21**, further comprising an optical connector disposed under the window so as to be contactable with a measurement target.

23. The reflection detection type pyramidal measurement apparatus of claim **22**, wherein the optical connector comprises a connection layer formed of a liquid material or an elastic material.

24. The reflection detection type measurement apparatus of claim **15**, further comprising an optical attenuation filter at the front of the second light source and the first optical detector, respectively.

25. The reflection detection type measurement apparatus of claim **1**, wherein the light source switching controller controls the first light source and the second light source such that turning-on states of the first light source and the second light source are separated from each other in time.

26. The reflection detection type measurement apparatus of claim **25**, wherein the switching controller is configured to detect the fluorescence signal and the reflected light signal from the first light source and the reflected light signal from the second light source while continuously repeating a process of sequentially turning on and off the first light source and the second light source.

27. The reflection detection type measurement apparatus of claim **2**, wherein the measurement target and the reference sample are selectively located on optical paths of the first light source and the second light source.

28. The reflection detection type measurement apparatus of claim **1**, wherein the first light source irradiates light with a wavelength of 370 ± 20 nm.

29. The reflection detection type measurement apparatus of claim **1**, wherein the second light source irradiates light with a wavelength of 440 ± 20 nm.

30. The reflection detection type measurement apparatus of claim **1**, wherein the switching controller controls all the first light source and the second light source to be turned off before turning on each of the light sources.

31. The reflection detection type measurement apparatus of claim **30**, wherein when the switching controller turns off all the first light source and the second light source, the first optical detector and the second optical detector measure dark signals, and the operator stores the measured dark signals and compensate for the fluorescence signal and the reflected light signal detected from the stored dark signals.

32. The reflection detection type measurement apparatus of claim **1**, wherein the switching controller controls the first light source and the second light source to repeat turning on/off at a period of about 10 Hz to about 100 Hz.

33. The reflection detection type measurement apparatus of claim **1**, further comprising an optical detector switching controller for controlling turning on/off of the first optical detector and the second optical detector.

34. The reflection detection type measurement apparatus of claim **1**, comprising:
a measurement scanner comprising the first light source, the second light source, the first optical detector, and the second optical detector; and
a main body electrically connected to the measurement scanner and comprising the operator, wherein an optical sensor is detachable from the main body.

35. The reflection detection type measurement apparatus of claim **34**, wherein the measurement scanner is formed in a hand-grippable form, and comprises the first light source, the second light source, the first optical detector, and the second optical detector disposed at one end portion thereof.

36. The reflection detection type measurement apparatus of claim **34**, wherein the measurement scanner comprises a memory for storing detected data.

37. The reflection detection type measurement apparatus of claim **34**, wherein the first light source, the second light source, the first optical detector, and the second optical detector are disposed so as to perform the light irradiation and the light detection from the same location.

38. The reflection detection type measurement apparatus of claim **34**, wherein the main body comprises a mounting part in which the measurement scanner is mounted, and the measurement scanner is configured to be removable from the mounting part.

39. The reflection detection type measurement apparatus of claim **38**, wherein the first light source, the second light source, the first optical detector, and the second optical detector are disposed at one end portion of the measurement scanner, and the mounting part has an aperture structure formed therein and having a shape matching a shape of the one end portion of the measurement scanner.

40. The reflection detection type measurement apparatus of claim **39**, wherein the aperture structure of the mounting part is configured such that the reference sample is optically connected to the first light source, the second light source, the first optical detector, and the second optical detector of the measurement scanner.

41. The reflection detection type measurement apparatus of claim **40**, wherein when the measurement scanner is mounted in the mounting part, the main body performs measurement on the reference sample, and receives detection data of the measurement target and the reference sample stored in the measurement scanner to allow the operator to calculate the corrected skin fluorescence signal.

42. The reflection detection type measurement apparatus of claim **38**, wherein the mount part comprises a charging terminal for the measurement scanner, and allows the measurement scanner to be charged when the measurement scanner is mounted in the mounting part.

43. The reflection detection type measurement apparatus of claim **34**, wherein the main body further comprises a display part, and the display part outputs the corrected skin fluorescence signal calculated in the operator.

44. The reflection detection type measurement apparatus of claim **1**, comprising:
a measurement scanner comprising the first light source, the second light source, the first optical detector, and the second optical detector; and
a main body electrically connected to the measurement scanner and comprising the operator, wherein the optical sensor is detachable from the main body;
wherein in the measurement scanner, the first light source, the second light source, the first optical detector, and the second optical detector are vertically disposed parallel to each other such that light irradiation and light detection is vertically performed on the measurement target.

45. The reflection detection type measurement apparatus of claim **1**, comprising: a measurement scanner comprising the first light source, the second light source, the first optical detector, and the second optical detector; and
a main body electrically connected to the measurement scanner and comprising the operator, wherein the optical sensor is detachable from the main body;
wherein in the measurement scanner, the first light source, the second light source, the first optical detector, and the second optical detector are obliquely disposed to be

inclined to each other at certain angles such that light irradiation and light detection is obliquely performed on the measurement target.

46. The reflection detection type measurement apparatus of claim **45**, wherein the first light source and the first optical, and the second light source and the second optical detector are all obliquely disposed at an angle of about 45 degrees with respect to the bottom surface of the pyramidal holder.

47. The reflection detection type measurement apparatus of claim **1**, comprising:

a measurement scanner comprising the first light source, the second light source, the first optical detector, and the second optical detector; and

a main body electrically connected to the measurement scanner and comprising the operator,

wherein the optical sensor is detachable from the main body;

wherein the measurement scanner comprises a pair of polarizers and a pair of cross-polarizers disposed thereon.

48. The reflection detection type measurement apparatus of claim **1**, comprising:

a measurement scanner comprising the first light source, the second light source, the first optical detector, and the second optical detector; and

a main body electrically connected to the measurement scanner and comprising the operator,

wherein the optical sensor is detachable from the main body;

wherein the first light source and the second light source are connected to an end of a measurement target side of the measurement scanner via a light guide.

49. The reflection detection type measurement apparatus of claim **1**, comprising:

a measurement scanner comprising the first light source, the second light source, the first optical detector, and the second optical detector; and

a main body electrically connected to the measurement scanner and comprising the operator,

wherein the optical sensor is detachable from the main body;

wherein the first optical detector and the second optical detector are connected to an end of a measurement target side of the measurement scanner via a light guide.

50. The reflection detection type measurement apparatus of claim **1**, wherein the operator calculates a skin fluorescence value corrected by the following equation:

$$\text{AFcorr}=K[I(\lambda 2,t1)/I0(\lambda 2,t1)]/\{[R(\lambda 1)]k1[R(\lambda 2)]\}k2$$

(here, $R(\lambda 1)=I(\lambda 1,t1)/I0(\lambda 1,t1)$: Diffuse reflection coefficient in excitation wavelength;

$R(\lambda 2)=I(\lambda 2,t2)/I0(\lambda 2,t2)$: Diffuse reflection coefficient in emission wavelength;

$I(\lambda 2,t1)$: Inherent fluorescence (skin fluorescence) signal value of skin tissue;

$I(\lambda 1,t1)$: Reflected light signal value of skin tissue in excitation light wavelength;

$I(\lambda 2,t2)$: Reflected light signal value of skin tissue in emission light wavelength;

$k1$, $k2$: Exponents of correction function with respect to excitation light and emission light wavelength;

$I0(\lambda 2,t1)$: Inherent fluorescence signal value of reference sample;

$I0(\lambda 1,t1)$: Reflected light signal value of reference sample in excitation light wavelength; and

$I0(\lambda 2,t2)$: Reflected light signal value of reference sample in emission light wavelength),

K: Ratio coefficient that considers the features of the used reference samples.

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